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ARCTIC MANUAL

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ARCTIC MANUAL

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Chapter 1

PHYSICAL GEOGRAPHY

Section I

TOPOGRAPHY

1. **General.**—Greenland has a proper ice cap. There is no real ice cap in any other Arctic land; there are glaciers in some of them but only in lands which are mountainous. Roughly, the height of mountains required for glaciation varies inversely with the precipitation. Latitude does not seem to be an important factor in glaciation north of 60°. Greenland, Arctic Canada, Alaska, and Siberia are fully covered in guidebooks and a brief sketch only is given here.

2. **Greenland.**—*a. Topography.*—(1) In the sense of land differentiated from ice, Greenland is low in its center with mountain ranges along both western and eastern coasts. The western range averages perhaps 7,000 feet in height, running to 8,840 feet at Camp Watkins; the eastern reaches heights of 9,000 to 11,000 feet, with the probable maximum of 11,500 feet at Mount Forel.

(2) Glaciers have filled the central land depression, flowing east from the western range and west from the eastern, till the basin is more than filled, having a flattened dome outline somewhat higher in places than any but the extreme peaks of the eastern range.

(3) At stations 300 to 400 miles inland from the east and west coasts respectively, measurements have been made by echo-sounding which show such ice thicknesses as 8,800 feet where the surface of the ice is 9,800 feet above sea level.

(4) Greenland is, then, for practical purposes a turtle-backed island continent, 600 to 800 miles wide generally and more than 1,600 miles long, with a maximum height of the turtle-back probably around 10,000 feet and with few if any passes across from east to west that are less than 7,000 feet high. The "divide" from which the ice slopes east and west is an irregularly curved line running generally north and south somewhat farther east than the middle of the ice dome.

(5) The coasts are the most rugged in the whole Northern Hemisphere, even more than the Norwegian or the Icelandic. Every valley is a path for seaward glacial flow, although the glaciers may not reach the sea. In a few cases it is more than 100 miles from the coast to the nearest land ice. A topographic map of Greenland provides the rest of the description.

b. Glacier crevasses.—(1) The reported gaping width of a crevasse at the top varies from less than 10 feet to more than 60 feet. Narrow crevasses are seldom reported because a narrow gap will be bridged over by snow which usually is strong enough to support men and dogs, and which might support taxiing airplanes.

(2) Crevasses are usually at right angles to the direction of ice flow and seldom extend more than part way across a valley so that each in its turn can be avoided by detouring.

c. Glacier travel precautions.—(1) In climbing or descending a glacier, men should be roped together in Alpine fashion, the distance between them being greater than the greatest width of a crevasse that can probably be bridged by drifting snow. This width will vary greatly. However, a distance of 20 feet between men advancing at right angles to the crevasses probably will be sufficient. Similarly, dog teams can follow each other with the harness of the leading dog of one team attached by a strong rope to the sledge next preceding. Distances between teams should be such that in the ascent or descent, not more than one dog team is likely to fall into a crevasse at one time. If a team falls through, the harness will suspend each dog until the team can be rescued. The danger is considerably greater descending a glacier slope, for if a leading team falls through it will be difficult for the teams and men behind to hold back. Proper procedure is to turn the teams sideways, upset the sledges and thus stop them from sliding.

(2) In summer the crevasses are not hidden, for the snow has melted away; nevertheless they form a very serious handicap in ascent or descent.

d. Extent of snow-free land.—Because of a combination of high mountains and a heavier precipitation, there is comparatively little snow-free coastal land near the south tip of Greenland; likewise, because of small elevation and light precipitation there is a large section of snow-free land at the north tip of Greenland—Peary Land. The widest sections of territory free from snow in summer are at distances between 200 and 500 miles northward from Cape Farewell along the west coast of Greenland (between about lat. 63° and 68° N.) and on the east coast at and north of Scoresby Sound (between lat. 70° and 74° N.). This snow-free area is not less than 20 percent of the total area of Greenland. In recent years it has been found that the Peary Land snow-free areas are even larger than believed and that "surprisingly large" ice-free lands exist in northeast Greenland. Elsewhere on these coasts there are narrow snow-free coastal strips broken here and there by glaciers which reach the sea. On the west coast there is one long stretch which extends from about lat. 74° to about 77° N., practically without snow-free coastal land.

3. Canada.—*a. Permanent snow and ice.*—Going west and southwest from Greenland the glaciers decrease rapidly. The amount of glacier ice and permanent snowbanks varies according to topography and precipitation. Practically all glacier ice and permanent snowbanks are to be found on the Canadian islands to the north and northeast of the mainland. There is a possibility that one island, Meighen, at 80° N. 100° W., has an ice cap. There are a few glaciers in the Yukon Territory, although the permanent snow in Arctic Yukon is less than 10 percent of that found in the non-Arctic part of the same territory.

b. Topography.—(1) There are no mountains in continental Arctic Canada until the very northwest, Yukon Territory, is reached. On the whole, Yukon is a mountainous region with peaks running up to 8,000 feet.

(2) The greater part of mainland Arctic Canada, outside Yukon Territory, is prairie.

4. Arctic Alaska.—*a. Topography.*—(1) In Arctic Alaska the Brooks Range separates the waters flowing southward into the Yukon, or westward into Bering Sea, from those flowing northward into the Arctic Ocean. Although spoken of as a unit, this range consists of many individual mountain groups—the De Long, Baird, Schwatka, Melville, and Endicott toward the south; the Franklin, Romanzof, Shublik, and Sadlerochit groups toward the north.

(2) Compared with other Alaska ranges, the Brooks is relatively low, with a few peaks between 7,000 and 10,000 feet high. Although

the height of the peaks and ridges makes them formidable barriers to travel, there are many gaps at lower elevations—both east-west and north-south—by which passage of the mountains can be made with reasonable facility.

(3) North of the Brooks Range is a triangular prairie. At the Alaska-Canada boundary this prairie is only 15 or 20 miles wide, from the sea to the rugged foothills. However, abreast of Barrow it reaches a 200-mile north-south width and disappears near Lisburne. Most portions of this prairie are so level near the sea and east of Barrow that it is difficult or impossible for the unaided eye to judge which way it slopes. The drainage system will give the best clue. West of Barrow, although not quite at Barrow itself, the land tends to increase in altitude more rapidly and perceptibly from the coast than elsewhere.

(4) In attempting to utilize the north coast of Alaska for any sort of supply depots or bases of operations, it must be taken into consideration that this coast is sinking rapidly. So long as the sea ice remains in winter and spring, nothing happens to injure the islands off the north coast; but, when the ice leaves, as it does nearly every summer, and a gale comes from the open sea, the waves undermine the cliffs of the islands with the result that the coast line sometimes recedes as much as a hundred yards in a single summer. The island of Flaxman is an example of this. When the early whalers came to the eastern north-coast of Alaska in 1889, this island was probably some 8 or 10 miles long. Thirty years later it was no more than half that length, having also narrowed correspondingly. What happens to north-coast islands is happening to that coast itself, especially where unprotected by off-shore isles and reefs.

b. Glaciers.—Glaciers are uncommon in Arctic Alaska.

5. Siberia.—*a. Topography.*—Generally speaking, the coast of Arctic Siberia resembles that of Alaska, although at places the mountains come nearer the less regular coast line. A good topographical map will show the location of the various mountain ranges, the lakes, and rivers and will indicate the general topography of Arctic Siberia.

b. Snowbanks and glaciers.—(1) No glaciers are found in the vast extent of mainland Arctic Siberia. Some large areas are also free of persisting snowbanks. Where there are mountains, chiefly in the northeast, persisting snowbanks and small glaciers are found where the mountains are rugged and relatively high.

(2) With the exception of Wrangel, the islands of the eastern Asiatic section of the Soviet Arctic are comparatively low and none of them contain permanent snow. Herald Island is almost a solid

mass of granite approximately 1,000 feet high. Wrangel has a mountainous plateau traversed by two longitudinal ridges and several deep-cut valleys. The highest point is about 2,500 feet, but no glaciers are found. The New Siberian Islands, which lie a considerable distance west of Wrangel, have greatest heights of between 1,000 and 1,200 feet.

(3) Proceeding westward, the first glaciated areas appear at Severnaya Zemlya. Approximately 45 percent of the entire area of this island group is covered with ice fields from which glaciers descend to the coast. The interior has plateaus 1,300 to 2,000 feet high. Novaya Zemlya is an island in two main parts. Its northern section, running down to approximately lat. 75° N., is largely covered with ice, with an average altitude of nearly 2,000 feet, the highest peak reaching an elevation of some 3,000 feet. The highest areas of a mountain range which stretches from north to south are in the central portion of the island where the glaciers begin to disappear. In this section the highest elevation is 3,350 feet. The land south of lat. 72° N. is generally low and flat.

(4) Vaigach and Kolguev Islands, south and southwest of Novaya Zemlya respectively, have no glaciers and no permanent snow. Most of Vaigach is swampy and filled with lakes, but there are two ranges of hills stretching from one end of the island to the other which reach an elevation of 300 feet in the center.

(5) In the northernmost and westernmost section of the Soviet Arctic lies the group of islands known as Franz Josef Land. They are mainly ice-covered plateaus rarely more than 1,000 feet high, with the exception of Cape Tirol on Viner Neishtadt Island which is nearly 3,000 feet high. Frequently the snow line comes down to 300 feet, the only bare area of considerable size being on Alexandra Land.

(6) Many shores of these islands are ice covered; but where there is no ice they exhibit a terrace formation with elevations ranging from 100 to 400 feet.

6. Svalbard Archipelago.—*a. Topography.*—(1) Between Novaya Zemlya and Greenland lies the Svalbard Archipelago.

(2) The chief island, Spitsbergen, is a much dissected plateau with many deep fjords penetrating far inland. Small plains are found in the north and west. Sharp peaks rise to 4,960 feet in Horn Sunds Tinder in the south, 3,450 feet in Mount Monaco on Prince Charles Foreland, and 4,770 feet in Mount Eidsvoll in the northwest. In the middle and east the mountains are flat-topped

and seldom over 2,000 feet; Mount Newton, 5,445 feet, in New Friesland is the loftiest peak in the archipelago.

b. Glaciers.—(1) Glaciers fill the valleys except in the southern interior where they have receded; they generally reach the sea, often along broad fronts, but give rise to no large icebergs. An ice covering over New Friesland is the nearest approach to an ice sheet in the Svalbard group. Barents and Edge Islands have glaciers only on the east. The Wiche Islands have no large glaciers, but North-East Land and Giles (Gillis) Land are each covered with a dome of ice that almost envelops them. Prince Charles Foreland has numerous glaciers.

(2) Isolated Bear Island, a part of administrative Svalbard but remote from (south of) the Spitsbergen group, rises to 1,630 feet in Mount Misery. The northern part is a plain at an elevation of about 150 feet. There are no glaciers.

7. Arctic lakes.—*a. General.*—(1) It is to be remembered that land which is described as flat will usually have from 40 percent to 60 percent of its surface represented by lakes of various sizes. Most of them are shallow and some of them are so shallow that a man can wade across a lake 1 or even several miles in width. This shallowness of lakes is important to remember in connection with ponton or flying-boat descents; but it is equally to be remembered that if the keel of a ponton or boat were to touch lake bottom it would encounter, 9 times out of 10, soft and slippery mud. For below the water of shallow lakes the "eternal frost" will thaw for several feet, although on the prairie between the lakes it will thaw only as many inches.

(2) In rolling Arctic country there will be fewer lakes than on the flat lands, although a considerably larger number than expected on such terrain in other zones. It is only in very rugged districts, practically mountainous, that the proportion of lakes to the rest of the country is about the same in the Arctic as would be expected in temperate or tropic zones.

(3) When the land is flat and the lakes are most numerous, some of the lakes will have no outlet; frequently they will be connected by sluggish streams.

b. Soil.—The proportion of rocky land is less in the Arctic than in the other zones, erosion probably being the primary reason for this. The lake bottoms are covered with soft and slippery mud or muck.

8. Ground frost and ground thaw.—*a. General.*—(1) Ground frost is related to several of the Arctic and sub-Arctic problems with which this manual deals. It has an important bearing on European-

American community life in the north and is of perhaps even greater importance in connection with road construction, aviation, the use of tractors, etc.

(2) On land in the sub-Arctic districts, where there is no permanent ground frost, 9 feet may be the maximum depth to which the winter frost of any year penetrates. Such depth occurs where the ground is swept clear of snow by the wind. There are few such places, only those without vegetation and with a smooth surface.

(3) For reasons upon which geologists do not as yet agree, there is permanent ground frost in nearly the whole Arctic and in a considerable part of the North Temperate Zone.

b. Land beneath a glacier usually or always unfrozen.—A theory for ground frost which no longer appears tenable is that it is a "relic of the Ice Age." For, logically, the frost goes down to that point where a balance is reached between the earth's interior heat and the chill that has penetrated down into the crust from the atmosphere. Now if there is, above the topmost layer of proper earth, a layer of ice perhaps thousands of feet thick, such as there now is in interior Greenland, then the point at which a frost-line balance will be reached between the atmospheric cold and the earth's interior heat should be very near the under side of the ice. Recently this has been proved true in at least a considerable number of special cases. Where glaciers are retreating, pits have been sunk into the earth and it has been found, in most if not all cases, that the earth beneath the glacier had not been frozen.

c. Ground frost.—(1) According to recent geological findings, there were great areas of land in the far north not glaciated during the Ice Ages. The northern plain of Alaska has always been free of glaciation, so far as geologists have yet discovered. That was the time, no doubt, and those were the circumstances under which the frost penetrated so deep that even today the north Alaska ground frost line is several hundred feet down.

(2) It would appear a conservative estimate that 50 percent of all British North America has permanent ground frost. A likelier estimate is 55 percent.

(3) Generally speaking, frost is to be found far south in British North America, chiefly east of the Red River of the North. In the prairie provinces the southern limit of frost runs northwesterly so that it is most southerly in Manitoba, intermediate in Saskatchewan, and farthest north in Alberta where the limit of sporadic occurrence is probably not far from Lesser Slave Lake. It may be equally far north in British Columbia. In Alaska there seems to be permanent

ground frost in all land north of the Brooks Range. The Yukon drainage basin is mainly frozen. South of the Alaska range divide much land is unfrozen.

(4) Perhaps because heavily ice-covered in glacial times, there is surprisingly little ground frost in northern European Russia. But the Soviet Union, mainly in Siberia, has a far larger total area of frozen ground than does North America. There, as in North America, the known limits of the ground frost are being moved farther and farther south the more complete the exploration. An approximation of the southern boundary was made in 1939 by Prof. George B. Cressey of Syracuse University. He considers that on the Pacific side the permanent frost occupies the northern half of the Kamchatka Peninsula as well as all land to the north. West of the Okhotsk Sea the frozen ground pretty well follows the coast south until Sakhalin Island is reached. Then the frost trends inland; somewhat west of Khabarovsk a tongue of it extends a little farther south than that city, or about to the latitude of northern Lake Superior. West of there the frost in some places goes a little south of lat. 50° N. and will be found even with the south end of Lake Baikal. Then it trends northwesterly, keeping mostly to the east of the Yenisei River, and runs northwardly to about lat. 65° N. where it crosses the Yenisei and trends westerly, coming to an end, or practically so, on the shores of the eastern White Sea. Altogether, Professor Cressey estimates that permanently frozen ground underlies 3,728,900 square miles of Soviet territory.

d. Special causes of thaw.—Geologists have reported thawed ground extending to an indefinite depth in some parts of Alaska where frozen ground is nearby. It should be borne in mind that Arctic rivers and even lakes will remove permanent frost from the ground for a considerable distance. The ocean does the same.

SECTION II

TIDES AND CURRENTS

9. Arctic Ocean.—*a. Sea.*—The Arctic Ocean, with its approximately 5,000,000 square miles, is tiny when compared with the Pacific, Atlantic, and Indian Oceans. This relatively small North Polar basin has on its margins a continental shelf, wide in most places when compared with shelves in the rest of the world; conspicuously narrow only toward Alaska. By ordinary definition, continental shelves have on them water 200 meters (650 feet) or less in depth. The

Arctic shelf, while still a true one in the sense that eventually it will descend rapidly to great depths, is likely to have on it water of 1,000, 1,300, or even 1,600 feet.

b. Sea temperatures and salinities.—It was discovered during the *Fram* expedition of 1893–1896 that the polar sea is covered by a layer 500 to 650 feet thick of cold water with temperatures between 32° F. and 28.6° F., and with comparatively low salinity owing to the admixture of fresh water—river water and products of rain, melted snow, and melted sea ice freshened through aging. Then there is a layer, some 2,000 or 2,500 feet, of warmer and saltier water with temperatures above 32° F. This is Atlantic water which is carried into the Arctic basin by the tentacles of the Gulf Stream reaching northward, perhaps chiefly along the west coast of Spitsbergen. Below this there is again colder water, probably filling the whole basin to the bottom, with temperatures between 32° and 30.6° F. and salinity about the same as that of the warm middle layer. This cold deep layer is presumed to originate in the northern part of the Norwegian Sea, north-northeast of Jan Mayen.

c. Pack ice.—Even toward the end of summer, two-thirds of the Arctic Sea is covered by drifting pack ice formed by the freezing of surface layers during autumn, winter, and spring. The pack is in motion during all seasons of the year, floes breaking up and drifting about through the effect of wind and current, with leads of water opening and closing between the various floes. Ice to average thicknesses of 7 feet, and not more than 10 feet thick, will form during 1 year's freezing; ice 2 or 3 years old may be 2 or 3 feet thicker. Pressure due to currents and wind may result in piled or raftered ice to a maximum thickness of 150 or 200 feet. These thick masses are seldom found far from land but occur chiefly at or near what is called the flaw, or floe, where the landfast shore ice meets the moving pack. Ridges may pile up that have peaks 60 or 70 feet above sea level. Far from land the ridges probably do not exceed 35 or 40 feet in height.

d. Planes can descend upon sea ice.—It is known from reports by the Papanin North Pole expedition that even the biggest landplanes can descend with safety upon such strong level fields as are found pretty much all over the polar sea in winter. The transport pilots who delivered the Papanin group and their 10 tons of supplies at the North Pole in 1937 made, between lat. 85° and 90° N., about 20 different landings with heavily loaded, half-loaded, and lightly loaded four-engine airplanes, practically the largest then in existence. Every descent was followed by a successful take-off.

e. Currents.—The tendency of the light surface layers of the Arctic Sea, with their low salinity, is to spread outward. This movement is helped by the prevailing winds and the overflow necessary from a constricted basin to which the inflow of river water is considerable and evaporation slight. Within the polar basin the surface waters are sweeping across from Alaska and Siberia toward Spitsbergen and Greenland. The Papanin expedition drifted from the North Pole to a point off the east coast of Greenland at an average rate of more than 3 miles per day. The current off the north coast of Alaska is considered to be prevailing westward.

f. Tides.—In most of the Arctic, tides, properly speaking, are insignificant—ranging, for instance, from 18 inches on certain parts of the north coast of Alaska down to 8 inches in Coronation Gulf. But there is at certain times a so-called "storm tide." When a strong southwest or west wind begins to blow around the north or northeast of Bering Strait, it produces a wave or swell that moves eastward and reaches the Colville Delta or Herschel Island possibly 8 to 12 hours ahead of the storm itself. This rise of water that presages a strong southwester may sometimes amount to as much as 5 feet; in advance of a moderate southwest wind the rise may be a foot or two. There is a corresponding fall with or before a northeast wind. On the north coast of Alaska, the directions of the winds are mainly from the southwest and northeast.

g. Life in the polar sea.—The number of seals, from the human point of view the most reliable and valuable of Arctic food mammals, varies in different parts of the ocean. This seems to depend neither on latitude nor on distance from shore but obviously depends on the mobility of the ice. Wherever there are strong currents, and consequent broken ice, for instance north of Alaska in lat. 73° or 74° N., seals are abundant though the shore may be far distant. In areas where the ice is sluggish and consequently very thick and little broken, a scarcity of seals is to be expected. Stefansson found one such region north of Borden Island, where seals were not absent but comparatively rare.

Section III

GLOSSARY

10. Ice terms.—*a. Young ice.*—Ice which has formed so recently that it is not strong enough for a man to walk on. Referred to frequently in connection with leads.

b. Old ice.—Ice formed last year or 2 or 3 years ago. Its pressure ridges and hummocks are still fairly angular.

c. Paleocrystic ice.—Ice several years old; some of it may be dozens of years old. The rains and thaws have rounded the fracture angles so there is the general but small-scale appearance of a rolling prairie.

d. Shore ice.—Landfast ice which at one edge touches and adheres to the beach, the other edge meeting the pack. Some of the shore ice is sometimes aground, especially because the pressure of the pack has crushed it up in the fall and early winter, piling it into ridges that draw a lot of water.

e. Flaw.—The meeting of the landfast shore ice with the moving pack.

f. Pack.—Ice of considerable extent and thickness, which is in constant motion or which is thought of as being so.

g. Shore lead.—Open water that appears when the pack moves a little away from the shore ice. When the pack is somewhere in the offing, open water is called a shore lead even when the water is so wide that no ice can be seen from the flaw or from shore. Only in summer, or after an offshore gale so strong that it produces summer-like ocean conditions, is the water outside the flaw spoken of as "the sea" or "the open sea."

h. Field.—A large coherent mass of pack ice several miles in area.

i. Floe.—An area of ice smaller than a field, such as acres or scores of acres instead of miles in area.

j. Cake.—Smaller than a floe, say from piano size upward. Smaller ice is called chunks, fragments.

k. Mush or brash.—Small chunks mixed with the finely ground ice which is the result of pressure between larger bodies of ice.

l. Hole.—An irregular opening in sea ice, square yards, square rods, or acres in extent.

m. Crack.—A break in ice so narrow that it can be stepped or jumped over and can be crossed fairly readily with dog teams and sledges.

n. Lane.—A crack too wide to jump across but so narrow that emergency methods frequently suffice for crossing. For instance, one can get men and dogs on a cake of ice, use it for a raft and paddle across; or, by man power, work an oblong cake crosswise in the lane so that it forms a bridge. This defines *lane* as used by sledge travelers. A sailor in a ship uses the same word to mean a passage through ice wide enough for his ship.

o. Lead.—A crack wider than a lane, from dozens of yards to several miles in width.

p. Pressure ice.—Ice which has been broken under stress of wind or current and piled up into ridges or hummocks.

q. Hummock.—A pile of pressure ice not particularly long.

r. Pressure ridge.—A long hummock or a linear series of hummocks of broken ice.

s. Sky map.—Reflection of the terrain in clouds. Water is represented in the sky as black; snow as white; ice more or less mottled according to amount of snow covering and character of the ice itself; land as black if snowless and mottled in various ways according to snow and vegetation; pink may show in the sky from "pink snow"; yellow or brown from faded vegetation.

t. Ice blink, land sky, water sky.—These are portions of the sky map as described above.

u. Needle ice.—Ice formed by the freezing of fresh water will in spring separate into crystals, each having the length of what was the full vertical thickness of the ice when it lay horizontal. These crystals will slide past each other in such a way that ice 2 or 3 feet thick will give way under the weight of a man. The tops of the crystals are so sharp that they tear the feet of dogs and rapidly wear out the boots of men on spring journeys.

v. Slush.—Slush, when spoken of in winter at sea, has a special meaning, the elimination of salt from brine by freezing. The process is the clearer in its stages the colder the weather. Assume a temperature of $-40°$ F. and an open lead. During the night ice forms so thick that next morning men and dogs can travel over it. If the intense frost continues a second day, without snowfall or drifting snow, the new ice will be fairly hard, although there may be on top of it a slight tendency to slush because it has been "steaming"—moisture has been evaporating and condensing again.

w. Fresh sea ice.—Ice produced by the continuation of the process described for the formation of slush, which results in the elimination of salt from the ice.

x. Snow on sea ice.—Snow on sea ice has a little salt mixed with it and is much like snow on land. Only toward spring does the snow at sea become a serious handicap to travel afoot. It then becomes *granular*, *mushy*, and men and sledges sink into it as if the drifts were bins of wheat.

y. Ice cap.—An ice sheet of great thickness with its center at or near the pole and extending with fair uniformity in all directions.

z. Inland ice.—A term used only for Greenland, where it is also used interchangeably with *ice cap*.

aa. Glacier.—In Greenland it is a stream of ice flowing slowly away from the inland ice through a valley or over the top of a ridge. When this glacier reaches the sea, it breaks off and forms icebergs. Outside Greenland, glaciers of the Arctic are about like those of Switzerland or of the State of Washington.

ab. Icebergs.—Large blocks of ice which have broken off from the edges of glaciers as they reach the sea. Some bergs are many hundreds of feet thick and several square miles in area.

ac. Ice foot.—Ice attached to glaciers extending to the sea, being to glaciers what shore ice is to sea ice.

ad. Crevasse.—A crack in land ice produced by its unequal flowing motion. In sea ice one does not speak of crevasses, merely of cracks or crevices.

Chapter 2

CLIMATE AND WEATHER

Section I

TEMPERATURES

11. Summer.—*a.* The maximum temperature recorded within the Arctic Circle by the Weather Bureau is 100° F. in the shade. While this record has been made only once, and in only one place, temperatures of 95° F. have been recorded at numerous times in many places. Heat of 85° to 90° F may be expected almost anywhere, no matter how far north, if the following conditions exist: low land, snow-clad mountains remote, distance from the sea more than 100 miles. At sea level on June 22, the sun delivers 3 to 4 percent less heat each 24 hours at the North Pole than at the Equator. Roughly, this means that in late August, 80 percent of all land north of the Arctic Circle is free of snow. Most of the snow-clad land, 20 percent, is in Greenland. In midsummer, temperature differences between night and day are, in the Arctic, small compared with those of tropic or temperate zones; for the sun, though not delivering so much heat when low, is nevertheless shining at midnight.

b. High northern temperatures are likely to be more distressing to people than the same temperatures farther south for three main reasons:

(1) In those parts of the Arctic where temperatures run high, all the land is a swamp. The heat is, therefore, very humid.

(2) The sun does not set, and at night there is not that relief from its heat to which people are accustomed nearer the Equator.

(3) Mosquitoes, sandflies, and other biting pests require that adequate protective clothing be worn, no matter what the heat, as against one's ability farther south to dress lightly or even to go partly naked.

12. Winter.—*a.* The most intense cold yet reliably recorded on the earth's surface is −90° or −94° F. (about 125° F. below freezing). Temperatures approaching this are likeliest where a lowland far from the sea is surrounded by mountains—that is the condition at the coldest spot in the United States, Riverside, near the Montana-Wyoming line, which is the same distance north of the Equator as Milan, Italy, and Portland, Oreg. The Arctic's coldest place, Verkhoyansk, Siberia, is similarly on lowland surrounded by mountains. All these record-holding localities are remote from the sea and its influences. All have hot summers and are forested.

b. There is probably no place on any seacoast in the Arctic Zone which can show as low a minimum as Riverside, Wyo. For instance, the lowest yet recorded by the Weather Bureau at Point Barrow, Alaska, over 300 miles north of the Arctic Circle, is −56° F. The lowest on the north coast of Canada is −52° F. at Herschel Island, 200 miles north of the Arctic Circle. In the Smith Sound region of Greenland, a low of −37° F. was reported for the winter of 1934–35. This record was taken some 500 miles farther north than the north tip of Alaska and some 800 miles north of the Arctic Circle. Since there is no known warm sea current nearer than 800–900 miles east, on the other side of Greenland, it must be ice water (water around 30° F.) that warms up the Smith Sound region—and most of it is water frozen over in midwinter, so there must be considerable radiation through sea ice.

c. Cold air being heavier than warm flows down the slopes into the valleys and pockets. This is why airplanes which take off from low ground in intensely cold weather usually find themselves flying at considerably warmer temperatures even a few hundred feet up, and much warmer half a mile up.

13. Physical effects of cold.—*a.* Perhaps the most conspicuous effect of cold on air is to dry it. A demonstration under practically laboratory conditions occurs whenever in cold weather a European-type door that leads out from a heated room is opened. At temperatures like −50° F. outside and 70° F. inside, and even with the air of the house fairly dry (as when there is no cooking), a cloud of steam rushing in along the floor is observed. This thins upward and somewhere around the middle of the door it ceases to be noticeable. Persons outside get the reverse effect. They see a cloud of steam

rushing out from the upper half of the door, densest at the top. The air is being dried in both cases. Along the floor the damp air of the house is chilled, producing moisture that starts settling toward the floor and which, if the conditions are just right, will strike the floor as hoarfrost. The air escaping from the upper half of the door is dried when it gets out, the vapor again appearing first as a fog and later turning to silver particles that flutter to the ground.

b. Air at $-50°$ F. is, no doubt, considerably drier than any that can be found at 100° F. over a tropical desert. However, the drying of a wet piece of cloth would be retarded several hundred, if not several thousand, percent by the 150° F. drop, through the moisture turning almost instantly to ice. It will take several days for a wet cotton handkerchief to dry in still air at $-50°$ F.

c. Probably the drying of the air is the chief, though not sole, reason for several of the atmospheric phenomena. At temperatures in the $-30°$ to $-60°$ F. range, there are various extreme phenomena of sight and sound. A person's hand, though apparently dry when pulled from a mitten, will steam at $-60°$ F. almost as would, at room temperature, a cloth soaked in boiling water. Moisture from a dry face or dry hands will cloud spectacles, field glasses, sextants. The moist eye produces more pronounced clouding and frosting of instruments; the breath is still worse, of course. (See FM 31-15 and par. 24 of this manual.)

d. Bodies of ice-cold water at low temperatures will steam as if they were boiling. Clouds will rise from flooded rivers, or from leads at sea, that resemble the smoke of a forest fire. Animals and power vehicles leave "fog tails" or "fog trails" behind. At $-60°$ F. or colder, there is a trail in the air behind running caribou or behind a speeding airplane, as if a smoke screen were being laid. An extreme report is that a reindeer, probably as dry as it could normally be, was invisible through its own steam at 10 feet. This report was made in an area where the temperature can be expected to reach lower than $-80°$ F. A reindeer or a horse can be invisible through its own fog, of course, only from one side—the side toward which the steam is slowing drifting.

e. Visibility is greater, the colder the air, providing it is not interfered with by condensing moisture. At $-50°$ F. one can see comparatively small objects two or three times as far away as at 50° F.; and remote things, such as mountains, acquire neither the purplish appearance nor the blurred outlines which are associated with distance. Consequently judging distance fairly accurately is not only almost impossible for a man unaccustomed to cold weather but even

to one who is used to it. For instance, after seven winters of Arctic experience, Stefansson mistook as a small hill a mile away what later proved to be a mountain 20 miles away. He walked toward it for several hours and it constantly seemed about as far from him as when he started, until perhaps within the last hour or so.

f. Flyers who took part in the International Polar Year Expeditions of 1933 have said that they could see as clearly at 50 miles in the Arctic as they could at 10 miles in the Dutch East Indies.

g. The powers of hearing, or rather facilities for it, are increased more than those of sight. Under ideal conditions, with a temperature of −60° to −80° F., one can overhear an ordinary conversation at distances from half a mile to a mile. One can hear a man stamping his feet on the ground at 2 miles. At 10 to 12 miles the barking of dogs or the chopping of wood with an axe can be heard.

14. Special aviation problems.—*a.* The icing of wings of airplanes in very cold weather may be due in part at least to atmospheric content, as well as to air temperature, since some flyers have never experienced it at all, while others have been brought down by it. There is seldom icing at 28° to 32° F., though it has been reported within this temperature range both from Alaska and the United States. There is probably little or none at temperatures above 35° F. Icing conditions of the rime type have been reported at temperatures as low as −40° F. According to American and Canadian Arctic testimony, the worst icing range is between 15° and 25° F.

b. There is a condition in Alaska which causes trouble in several kinds of weather. It is the deposit of frost or rime (as opposed to ice) on the wings which changes their contour. This frost is frequently seen on airplanes that stand overnight, even in perfectly clear weather, and it is standard Alaska practice to sweep wings, propellers, and other parts clean of frost before taking off in the morning. If an airplane is left standing for any length of time during the day, frost is likely to gather again, necessitating further sweeping. In extreme and infrequent cases, frost in quantity sufficient to cause trouble has been known to collect while an airplane was taxiing down the runway for a take-off. This frost accumulation may occur at almost any time when temperatures are low, no matter how clear the air may be. In fact, it occurs more frequently on clear days than on days of light fog.

c. In winter, temperature inversions occur frequently and are most pronounced on the calmest days. This depends on cold air being heavier than warm. It may be said that temperature inversions are greatest in the coldest weather and that the intense cold at ground

levels is the result of settling cold air or cold ground. Usually, in temperature inversion, air near the ground is both heavy and dry.

d. When there is a wind, the air is churned up; and if the wind is at all strong, the inversion disappears completely for all practical purposes. The greatest inversions undoubtedly occur in those topographic configurations which produce the greatest cold. They occur most often at considerable distances from the sea and are most pronounced where a low land is surrounded by high mountains. There is said to be an ideal configuration of this sort at Oimekon, Siberia. Given below are some examples of temperature inversions:

(1) Alaska, Circle Hot Springs, ground, −49° F.; 2,000 feet up, 30° F.

(2) Canada, northeastern coast, ground, −49° F.; 1,000 feet up, −7.6° F.

(3) Canada, Mackenzie district, ground, −60° F.; 1,500 feet up, −25° F.

SECTION II

WINDS AND GALES

15. At sea.—Nansen said that it was an outstanding conclusion from his studies that the Arctic, taken as a whole, is less stormy than perhaps any other region of equal size in the world. He gives maximum wind velocity for 3 years at sea, 100 miles and more from land, as 50 mph. Stefansson considers he has never seen more than a 50-mile wind when more than 50 miles from shore. These are winds measured only 10 or 20 feet above ice-surface level at sea. The observations of Harald U. Sverdrup with balloons would indicate somewhat stronger winds aloft.

16. On land.—*a.* Statements are frequent in print that howling gales are numerous, or even that gales blow steadily for weeks on end. What such travelers have meant when they said that the Arctic was stormy can be interpreted that they observed strong gales where they happened to be and did not realize they were local.

b. Stefansson considers that a reconciliation of the statements may be found by comparing his experience far at sea on sledge journeys with his experience at Langton Bay (between Cape Bathurst and Cape Parry). On this occasion, he was traveling from inland north toward Langton Bay. When he was still 8 or 10 miles from the coast, a perfect calm changed to gentle breezes at his back. The

wind continued to increase as he approached the escarpment of the 1,500-to-2,000-foot plateau which is here 3 miles back from the sea. On beginning the descent, the gale was terrific. The land was bare except that here and there patches of snow had been pounded till they were like glare ice. Pieces of slate were torn from the cliffs as he descended a ravine and these went spinning down ahead of him. As he traversed the mile of flat land between the foot of the escarpment and the base camp of his expedition on the Langton Bay sandspit, the cartwheels of slate kept overtaking and passing him. Going north beyond the camp, along the land which runs toward Cape Parry, he found the wind steadily decreasing. In 3 or 4 miles, it was a gentle breeze again. Looking back, he could not see the cliffs for snowdrift, although the weather was otherwise clear.

17. Local storm areas.—*a.* The general statement can be made, as concluded by Nansen, that the Arctic as a whole is not a windy place. This is qualified by saying that there are regions of intense local storms, usually where high land faces the open sea. The most conspicuous examples are found in Greenland. While the center of the Greenland Inland Ice is probably on the average quiet, the coasts are probably the windiest regions of the Northern Hemisphere. However, it is found that gale violence does not usually extend more than 10 or 15 miles out to seaward.

b. With a good topographical map (preferably contoured), a knowledge of the sea areas, and consideration given to statements in the paragraphs immediately preceding, Arctic weather can be forecast in a general way; similarly, it can be determined where local gales are to be expected.

SECTION III

PRECIPITATION

18. Average precipitation.—It is difficult to measure Arctic snowfall, because the snow is usually dry and fluffy and is driven about a good deal by even the lightest winds. There is no doubt, however, that on the average Arctic precipitation is very light. It is estimated that, if the snow of winter was added to the rain of summer, the result would be about 8 inches of water, certainly not more than 10, on most parts of the Arctic lowlands of Canada and Alaska. The Siberian lowlands may be even drier.

19. Causes.—*a.* Precipitation depends mainly on two factors:

(1) The amount of moisture in the air.

(2) The factors that bring the air to the condensation point.

b. In a country such as Iceland, frequent and vivid examples are observed of the role played by mountains. In few countries is there a more abrupt rise from the sea, although there are often low coastal stretches. The air moving in from the sea and across the low areas will be perfectly clear. When it strikes the mountains, however, the precipitation gradient is observed to be related to the slope of the mountain. There is slight evidence of precipitation low down on the slopes. As the eye travels upward there is increased precipitation until the higher part of the mountain is concealed from view by a cloud from which rain or snow is falling.

c. The topography of Greenland is a major factor in the precipitation which deposits enough snow to maintain the Inland Ice. If Greenland were a low country, many of the winds would, no doubt, sweep all the way across it without producing rain or snow. Lack of mountainous areas explains partly why Peary Land in the north of Greenland is mainly snow-free toward the end of each summer. The same reasoning explains why most of the islands north of Canada have no glaciers, or neglible ones, and why the glaciers found are in the easterly part of the archipelago. They do not have flowing over them air that starts out with a higher degree of moisture, but they do have mountains which capture moisture.

20. Periods.—*a.* Most of the Arctic has the heaviest precipitation in the spring. On the north coast of Alaska from which it is so difficult to get instrumental verification, there is a consensus among observers that more snow falls during April, May, and the first part of June than during the remaining 9½ months of the year. It rains a good deal in summer, so that if the rain were snow it is possible that the summer precipitation would impress observers as much as does that of the spring. The fall of the year is inclined to be cloudy, and snowfalls are frequent but on an average are light in comparison with spring. From November to March, inclusive, the precipitation is light.

b. In their frequency and denseness fogs run somewhat similar to snowfalls. Both are heavy in spring. The summer rains may approximate in water content the spring snows, but the fogs of summer are markedly lighter and fewer than those of spring. In autumn both fogs and snowfalls are frequent, but neither of them is as heavy as in spring. In winter, fogs as well as snows are few; the fogs, however, are less frequent than the snows. These general remarks

on fog must not be understood to contradict what is said elsewhere specifically about *local* fogs.

Section IV

FOG

21. Coastal fogs.—*a.* Arctic lands are, generally, warmer than the seas in summer, colder than the seas in winter. Accordingly, coastal fog over land or sea is produced by the same kind of conditions as produce fogs in any other coastal region.

b. A fluctuation of the winds produces a fog belt more or less parallel to the shore, covering a strip of land and a strip of bordering ocean. Where a peninsula juts out into the sea, the entire peninsula, unless very wide, will have the coastal climate, though not as pronounced along the median line of a wide peninsula as along its shores. Similarly, a bay of cold water is often foggy in summer, for some land wind will be frequently blowing across it. The shore to the lee of the bay will be foggy.

c. The rule, to which there are exceptions, is that coastal fogs are fewest in winter, the longest season of the year; more numerous in midsummer; still more numerous in autumn; and of greatest frequency in spring.

d. It would seem that in midwinter, when the land is coldest, a land wind would most quickly produce a fog at sea. This would be true if the sea were not frozen, and is true when the ice has been blown away or its formation has been prevented. However, ordinarily the sea near land is covered with such thick ice in winter that a land wind does not produce much of a sea fog. Similarly, the ice covering of the sea prevents a sea wind from producing spectacular land fogs in winter.

22. Characteristics.—When the temperature is 50° or 60° F. in the shade, the fog caused by a sea wind is densest somewhere between 5 and 10 miles inland from the shore, while its farthest extension inland would not be much beyond 20 miles. Most of these summer fogs are low, whether on land near the sea or at sea near the land. For instance, on the sea off the north coast of Alaska, whaling captains often can see each other, crow's-nest to crow's-nest, when sailors on deck cannot see from ship to ship. Inexperienced aviators may

remain grounded for days under such conditions, not suspecting that moderate hills, and even a hundred-foot mast, will show above the fog.

23. Belts and times of poor spring visibility.—*a.* The Canadian Archipelago (Borden and Meighen Islands) has spring and early summer belts of almost continuous bad visibility—the fogs and snows of spring merge into the fogs and snows of autumn, with not a very appreciable slacking between. However, it is not necessary to go far southeastward into the Archipelago to note an improvement in midsummer.

b. A line drawn from Meighen Island southwest, and touching western Bordan and Prince Patrick, runs through a belt which has probably the worst visibility in the Arctic between May and November. Not only are fogs in this region about the most frequent in the Arctic, but they are also about the most complicated in their sources. For here are three fog-producing factors in a rare combination—the islands in summer generating heat, the sea ice remaining motionless between the islands either far into, or throughout, the summer and the sea to the northwest lying partly open, with a great deal of mobile ice. On most coasts, there are only two of these three factors, the land and the open sea. There is, however, an almost equally complicated situation in Greenland where there is at a corresponding season the heat-generating coastal strip lying between the cold open sea and the still colder inland ice.

24. Fogs and special aviation problems.—Some of the special forms of fog that may be encountered in the Arctic, a majority of them produced by low temperatures, are described below:

a. (1) When water smoke lies over flooded rivers, the airplane normally has to be flown at least 500 feet high to keep clear. It is similar in appearance to the smoke of a small forest fire and does not spread any great distance. On land, a possible source of water smoke is unfrozen lakes. Most lakes freeze over early in the fall before the weather is cold enough to produce smoke; but Great Bear Lake (and possibly some other Arctic lakes or lakes on the margin of the Arctic) is so deep that it may have open water as much as 2 months after the freezing of small ponds. Under such conditions, water smoke may rise in quantity, though probably not to a great height.

(2) A still more rare source of water smoke is springs that come from a hillside too warm for quick freezing. These need not be warm springs in the usual sense of the term. Of course, warm and hot springs produce, in ratio to their size, very conspicuous smoke.

For instance, in Iceland, where boiling springs during summer distinctly give the impression of steam, the same springs in winter will give the impression of smoke, even though the temperature which enables them to do so is below Fahrenheit zero. This phenomenon led to the naming of the capital city, Reykjavik, *Smoky Bay*. This name will appear inconsistent to anyone who has seen Reykjavik only in summer, but to those who have seen the bay on a cold and clear day in winter the name seems very appropriate.

b. (1) Human-animal fog is of the same nature as invisible perspiration. A normally moist (apparently dry) hand will show as much steam at −60° F. in calm clear weather as a towel wrung in boiling water shows in a room at +60° F. Transfer this standard to other sources of "steam" and one has the basic idea of human-animal fog.

(2) Alaskan and Canadian flyers report that in the early morning, before and around sunrise, with a ground temperature of −50° to −65° F., fog is usually or always noticeable over villages. The steam (together with smoke in some cases) makes a "ceiling" at a few hundred feet. The fog will disappear if the sun develops heat or if a wind comes up. Flyers, knowing the condition to be local and temporary, take off from within these local fogs and are almost immediately out of them.

(3) At Fairbanks this fog sometimes extends a half mile or more beyond the limits of the town. When flying directly above that town nothing is usually obscured; visibility is perfect—one sees the town clearly through its fog. But flying at an angle, the town is blurred or hidden.

(4) Flyers can pick up a town by the fog bank over it. Finding such a fog bank and flying toward it, one will come either upon a town or upon open water. But the reverse may happen—a pilot may not be able to see a local fog that hides a town. One danger, then, is that the pilot may think himself off his course when he is not. For instance, he may plan to identify a river by a town located on it. If he does not see the town, in apparently perfect weather, he may think himself on the wrong river.

(5) The houses in one edge of a village are usually visible, for the air will have some movement, and the windward side of the town will be exposed. Similarly, an entire band of caribou or reindeer is seldom hidden—one will see at least a few animals on one edge of the herd.

c. On some days, airplanes flying in the Arctic will leave a fog tail 15 to 20 miles long that hangs still (straight) in the air or may

become wavy. One flyer, setting out after another whose machine has disappeared from view, can track the pilot to his destination by following the tail that is hanging in the air. Canadians have reported fog tails 18 miles long in the lower Mackenzie.

d. (1) "Spicule fog" as described below, looks more like a snowfall than a fog—it is as if snow were forming before one's eyes and then slowly falling.

(2) (*a*) Dr. Ralph L. Belknap, leader of the Michigan-Pan American Airways Expedition, reported spicule fogs from the Greenland Inland Ice. He gives the conditions under which they occur.

(*b*) Because of the relatively low-air temperatures over the interior of Greenland, the relative humidity is invariably high (that is, the precipitation point is not far off). When condensation occurs, it is most often in the form of ice spicules. Especially during the early morning hours, when the temperature is less than 10° F. the air, although cloudless, contains many small glistening particles falling slowly in the nearly motionless air. If there is a slight air movement, the particles have a tendency to collect and adhere to the lee side of obstructions.

(3) On the Inland Ice these particles sometimes are in quantity sufficient to obscure objects usually plainly visible. Such "fogs" develop in periods of low temperatures, high humidity, and calm to light winds. Dr. Belknap believes the fog effect is confined to a zone of limited vertical extent (a few hundred feet).

(4) Spicule fogs pronounced enough to be dangerous to airplanes are apparently very rare in all those parts of the Arctic where flying has been developed extensively. They are seemingly more frequent on the Inland Ice than anywhere else. An indication of their rarity is afforded by the absence of reports of trouble from all the flying yet done in Arctic Canada, according to the information of one of the most experienced of Canadian flyers, W. E. Gilbert. Only two Alaska cases are known to Pacific Alaska Airways; but they were serious, producing a heavy coating of frost on the wings just after the take-off or just before the landing so that the airplanes came down out of control.

e. Reported as a hazardous fog is the "black bank" which Canadian flyers have found in March low over the ice of the frozen sea in the district from Mackenzie River to Cape Parry. It is most dangerous where the coast is flat, and is more noticeable on overcast days. Flying along a flat coast, such as the Baillie Islands neighborhood, the "black bank" gives the appearance of a high coast line, since the fog resembles a high cliff.

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SECTION V

BAROMETRIC PRESSURES

25. Pressure distribution.—*a.* Here is summarized and paraphrased what Sverdrup has said on Arctic barometric pressures in his two main publications, Volume II of the *Norwegian North Polar Expedition with the Maud 1918–25, Scientific Results*, Norway, 1933, and in Band II Teil K of the Koppen-Graz-Geiger, *Handbuch der Klimatologie*, Berlin, 1935:

(1) In winter (January), the Atlantic side of the polar sea is under the influence of a low-pressure trough, extending from Iceland toward Cape Chelyuskin, Siberia. On the Siberian-American side, the pressure distribution shows a saddle point between the low-pressure sections south of Spitzbergen and over Bering Sea; another saddle point is found between the high-pressure regions over Siberia and Canada-Alaska. Between these high-pressure regions there appears a disturbing zone, within which deep winter cyclones are formed. These, moving in a northeasterly direction, later turn around and reach the Canadian Archipelago from the northwest.

(2) In the spring (April), high pressure predominates over the greater part of the polar sea and the Canadian Archipelago. During this time of the year, the disturbances are much smaller than in winter.

(3) In the summer (July), the pressure differences are very small over the entire region; the disturbances are frequent, but slight. The direction of the wind indicates higher air pressure over the northern part of the archipelago, but this is not borne out by the observations of pressure. All differences are, however, slight.

(4) In the fall (October), a transition to winter pressure distribution takes place, with a saddle point north of Bering Strait. From this month onward, strong disturbances again occur.

b. As in lower latitudes, the greatest number of disturbances occurs in the winter, when the air pressure is generally high. The mean monthly fluctuations of air pressure are here, as elsewhere, greater in winter than in summer.

CHAPTER 3

LIGHT IN POLAR REGIONS

SECTION I

GENERAL

26. Periods of daylight.—*a.* A practical way of differentiating between daylight and darkness is to say that it is not dark so long as a man of normal sight can read ordinary print out-of-doors. By this definition, there is at the North Pole (at lat. 90° N.) each year approximately 7 months of daylight and 5 of darkness.

b. Darkness may also be considered as that period when no daylight can be seen anywhere in the sky. On that basis, there is at the North Pole yearly about 8 months of daylight and 4 of darkness.

c. It is never pitch dark inside either of the polar circles except where a sea without ice exists, as to the north and northeast of Iceland. In summer, when land in the Arctic usually is black, brown, or green, there is perpetually either sunlight or twilight. In winter, when direct and indirect sunlight are both absent much of each day, the ground is usually white with a snow covering which so reflects and magnifies whatever light gets to it that, even at maximum darkness, one can probably see a dark-clad man on a white field at least 100 yards away. Maximum darkness occurs when the sky is densely overcast, when there is no twilight, when there is no moon in the sky, and when there are no northern lights behind the clouds. Even at such times enough light from the stars is transmitted through the densest clouds and reflected by the snow to prevent that type of pitch darkness which is common in the nonpolar zones.

27. Daylight in earth's zones.—Because of the shape of the earth, its relation to the sun, and refraction of light in the atmosphere,

there is some daylight at any given moment over about 66 percent of the earth's surface. This means that at either pole there would be daylight, from the first of spring to the last of fall, continuously for about two-thirds of the year. There is most daylight per year in the polar zones, intermediate in the temperate, least in the tropics, since refraction increases with decrease in temperature.

28. Conditions causing more effective light in polar zones.—The main reasons why there is more effective light in the polar zones than people from outside them expect are the following:

a. Air transmits light more easily when it is dry. Chilling the air dries it. The air over the polar zones during winter, therefore, transmits light more nearly perfectly than is common even on deserts.

b. The Arctic is mostly sea, lake, or swamp. Accordingly, less dust escapes into the air than is usual; and dust-free air transmits light better.

c. There is not as yet in the Arctic any considerable pollution of the air by the smokes of industry or even by those of numerous dwellings. Forest fires are rare; and there is less chance of volcanic dust than in most places, although there is a certain amount of vulcanism on the fringes of the Arctic in two sectors—Iceland and the Aleutian Islands. The absence of these smokes contributes further to the clarity of Arctic air.

d. The sun stays above the horizon for somewhat more than half each year. After the sun sinks below the horizon in the autumn, and before it attains the horizon in the spring, there is a twilight made brighter through the previously described clarities of the air and which is increased in brightness by reflection from the snow.

e. The stars, least considerable of the sources of light, succeed in delivering a higher percentage of their light in the Arctic than in the temperate or tropic zones. In addition, the light they do deliver is increased in effectiveness, perhaps doubled, by reflection from the snow; so it can be said that the Arctic stars give light between two and three times as effective as that of the stars of other zones.

f. The same increased quantities of delivery and the same multiplication by reflection apply also to the moon. A rough check has been made with a number of polar travelers, both Arctic and Antarctic, who agree that on a cold, clear midwinter night there is more useful light from half a moon on a snowy landscape than from a full moon shining on a green landscape.

29. Night landings in Arctic.—*a.* With a clear sky, one can see a mountain range as far by the light of stars and half a moon as one can by sunlight. Several Arctic pilots have written agreeing that

it is possible to land an airplane about as safely with half an Arctic moon as with daylight. Some informants have said that, while there is not quite as much light with half a moon as would be ideal for landing, there is compensation in the freedom from the glare that sometimes interferes with snow landings during full daylight.

b. Some experienced flyers disagree that the light of half a moon is adequate for safe landings, and they feel that really sufficient moonlight is present only for the 2 or 3 nights at the immediate full. These flyers, however, are all from Alaska; all have their main experience in the Yukon Valley, not on the prairie north of the Brooks Range or on the Arctic coast. This brings out an important fact—that clumps of forest scattered here and there about an otherwise snowy landscape detract considerably from its total reflecting effectiveness. For one thing, the moon is usually at a slant so the trees not only absorb the light which strikes them directly but they also throw a shadow over some of the landscape. Then there are shadows thrown by rocks and cut-banks. Cliffs are usually dark because they are steep. Mountain slopes are not on the average as clear in moonlight as are horizontal landscapes.

30. Arctic moonlight.—*a*. A considerably higher percentage of the moon's light is available for human use in northern Alaska than in southern Texas. In Texas the moon sets every night whether in the new or the full phase, while at Barrow the moon does not rise at all when it is new and does not set at all when it is full. People at Barrow lose little light from missing the moon that has so little light to give; they gain a lot from never losing the light of the full moon.

b. The moon at its full stays above the horizon only between 1 and 2 full days at the Arctic Circle. At the North Pole, it rises just a little before it is half full; then it stays in the sky through the full until it is a little less than half. Figuring a lunar month as 28 days, the moon is visible for about 15 and invisible about 13.

31. Aurora Borealis.—*a*. A special aid to visibility in the Arctic night is the Aurora Borealis. At its brightest, it may give as much light as the full moon—some say more. However, the Aurora Borealis is the least dependable of the lights—one never knows when it will come nor when it will fade. But it is at times very useful, sometimes aiding materially throughout the whole night.

b. An advantage of moonlight over sunlight is that it throws more sharply defined shadows or appears to do so; and shadows give an airman his one possibility of telling the difference between a level and a rough snow or ice surface when he is coming down for a land-

ing. It is, therefore, a serious defect of auroral light that it never comes from a single focus, like moonlight, and seldom even from a small part of the sky—more often it comes from several points of the compass and occasionally from nearly all of them. Coming from several directions, the aurora throws no clear shadow; if it is very bright, it may interfere so much with the moon's power of making well-defined shadows that for airplane landings at least the increase of light through the aurora is more of a hindrance than a help.

Section II

SPECIAL CHARACTERISTICS

32. Sunlight.—*a.* Sunlight reflected from water produces quick and violent sunburn. Sunburns are also quickly produced by the glare of Arctic snow. For protection, dark veils are sometimes worn.

b. When the sun is well above the horizon and the sky uniformly, though not densely, overcast, there is the maximum of eyestrain and tendency to snow-blindness. From the point of view of the traveler, both ground and air, the light under these conditions is the most difficult of all. Apparently, snow-blindness is not contracted by pilots while aloft. On sea ice, or on land uniformly snow-covered, one is literally unable to see anything that is white. For invisibility, it is not necessary to have snow-whiteness exactly matching the landscape. For instance, a polar bear, in reality yellowish-white, may be invisible as he approaches, except for his black nose. Having seen the nose, it may be possible to use it as a guide to locate his eyes and perhaps his claws or other dark spots and even a faint outline of his body. Under conditions where a bear is invisible at a distance of 100 yards, a blue fox may be visible a mile or more away. It is conditions such as these which may cause a person to walk off a precipice or to step into a crevasse inadvertently.

33. Arctic light phenomena.—*a.* With the general statements on light which follow is coupled a group of phenomena which are pronounced in the Arctic and important for winter travel.

b. From the temperate zones and Tropics come some examples which prepare for the more clear-cut phenomena of polar regions. For instance, in the temperate and tropic zones, when the clouds are just right, it is possible to see the lights of a city reflected in them at great distances, particularly on prairies. In the mountains, even

in the Tropics, when the clouds are just right, it is possible to see white patches in the sky surrounded by dark. The white ones are the reflections of glaciers; the dark are over the snow-free parts of the mountains.

c. Far at sea, on a day completely and uniformly overcast, with clouds at fairly high levels, the reflections on the clouds provide a real map of the surroundings. The higher the clouds the greater is the area of sea pictured in the sky.

d. Cloud areas below which level ice is uniformly covered with snow will be a uniform white on the sky map. Broken surfaces with many pressure ridges can themselves never be quite uniformly white and are, therefore, represented above by a slightly mottled appearance. One kind of ice surface, the paleocrystic, has been converted by many summers of rains and thaws into a small-scale equivalent of an undulating prairie. The hollows are choked with snow; and the high areas that have been swept free of snow are blue in appearance. Paleocrystic floes are reflected in the sky by round or oval dark patches in a matrix of white.

e. The sky map shows leads in their full variety of manifestations. Those which are several weeks or months old are smoothly snow-covered and are, therefore, shown by the clouds more uniformly white than any other ice; and long ribbons in the sky represent them cleanly. Other leads have ice from one to several days old, and they are represented by sky ribbons of various degrees of darkness. Those leads in which the water is still unfrozen are shown the darkest of all, practically black.

f. A special type of sky coloring begins to appear in spring when temperatures start running from −20° F. in the late night to +20° F. in the late afternoon. A general pinkish tinge will be observed in large patches of the sky map, most pronounced in certain places and sometimes giving a definite pattern to the sky. This shows that the tiny plant known as "pink snow" has begun to develop.

g. When approaching land in winter or early spring, a general darkening of the sky is first visible. This is not as pronounced as if caused by open water. There are certain patterns in the sky map which are recognized as showing land formations, and there is an amber or yellow tinge due to the bleached grass which sticks up here and there through the snow. If there are in the land sky a few patches as dark as over water, they are sandy or rocky stretches or land where the wind has swept all the snow away.

34. Value of sky map to aviator.—*a.* A flyer passing over the northern sea, having a wider horizon, does not need the sky map

quite so much as ground travelers; but even to him it will be useful. His method of interpreting the sky map will, of course, have to be different since he is likely to be near the clouds and will, therefore, have a different perspective.

b. Wilkins, who got accustomed to using the sky map as a traveler afoot on the northern pack, makes a suggestion for a novice in Arctic flying. If the aviator is below the clouds and close to them, he can make practically no use of the reflected map. In practice on such occasions the aviator should go down as low as he safely can, for the lower he is the more accurately and easily can he read the map.

c. In making this suggestion, Wilkins had in mind chiefly the problems of landing. If a pilot is flying a craft with wheels or skis and wants to make a landing, or thinks he may need to do so, he should select from the sky map patches that are uniformly white, since mottled or peppered patches indicate the rolling paleocrystic ice or recently fractured ice. If in a flying boat, the aviator should look for uniform black patches since these indicate open waters free or nearly free of drifting ice fragments; if these black patches are not found in the sky map, he should seek, as an alternative, a uniformly white patch and make a snow landing.

CHAPTER 4

INSECTS

35. General.—In comparison with temperate zones and the Tropics the Arctic has fewer species of insects, but some of these are in great numbers. They are discussed in the order of their importance—mosquitoes, sandflies, bulldogs, and blackflies.

36. Mosquitoes.—*a.* There are probably 10 times as many mosquitoes per square mile over at least two-thirds of the land north of the tree line as the highest average over an equivalent area in the Tropics. These mosquitoes do not kill except by actually sucking blood. Perhaps there is a small degree of direct poisoning as well; but the mosquitoes do not infect the victim with disease, certainly not with malaria or yellow fever.

b. The mosquito season lasts from the middle of June until the heavy frosts sometime in September. The most severe annoyance is usually experienced from about the middle of June to the middle of July.

c. For mosquito protection there are needed—

(1) Clothes to cover the entire body, through which mosquitoes cannot sting. This means reasonably heavy garments, leggings to protect ankles, gauntlet-type gloves, and a suitable hat.

(2) Mosquito net of bobbinet or similar material, with an elastic band at the top to grip the crown of the hat. The material should pass over the brim of the hat and should be tucked inside the coat collar; when the netting hangs down like a sort of cape, the mosquitoes crawl up under in great numbers.

(3) For individual protection while sleeping, a bed net of fine mesh. Ordinary mosquito netting is not good enough for the Arctic, because sandflies can crawl through it. As netting tears easily in trying to tuck it under bedding, there should be at the lower edge of the netting wall about a foot of light cloth which can be tucked in.

37. Sandflies.—*a.* After the mosquitoes have been in evidence for a while, there develops a pest which in some respects is worse. This

pest varies in size and is known variously as the *sandfly*, *punkie*, *midge*, or *no-see-um*. These sandflies are found in numbers large enough to be a pest only on the mainland. They are particularly numerous in forests and are found far out on the Arctic prairie.

b. In many places this pest is evident later than the mosquito and tends to persist later in the autumn. Mosquitoes are bothersome at night as well as in the day; but sandflies or midges are worse at noon and in the afternoon, decreasing their activity as the evening cools.

c. Sandflies are persistent bloodsuckers and are so small that they can go through ordinary screens or head nets. Their bite both hurts and itches.

d. Individual protection is the same as for mosquitoes, with one exception—the wearing of summer cotton underwear which has tight elastic at the ankles and wrists to prevent sandflies from crawling under.

38. Bulldogs.—*a*. The third of the major pests, from the human point of view, is the bulldog, sometimes called *moosefly*, *deerfly*, or *horsefly*. These insects look like overgrown houseflies and their bite is similar to a cut with a surgical instrument, which draws blood that trickles.

b. Bulldogs are present only on hot days; they stop annoying people toward sundown when it is cooler. On a cool day they are not bothersome; however, a strong wind does not keep them away.

c. Individual protection is the same as for mosquitoes.

39. Blackflies.—*a*. Blackflies are sometimes called *buffalo gnats* and are bad pests in certain Arctic areas. They do not constitute a real pest along the northern edge of the forest area, but they do become a pest well within the forest.

b. These flies begin to appear early in the summer and become most numerous and vicious during the first half of the season. As the summer progresses, their activity decreases. Bad swelling follows severe bites on the hands and face by these flies.

c. Individual protection is the same as for mosquitoes and sandflies.

Chapter 5

VEGETATION

Section I

VARIETY

40. Species of flowering plants.—*a.* Markham, in his *Life of McClintock*, says that there had been at that time (1908) 250 species of mosses, 330 of lichens, and 760 of flowering plants identified in the Arctic. Thus, in species, the flowering plants outnumber the nonflowering. In tonnage, the preponderance of the flowering is still greater. There is perhaps no island in the Arctic of the size of Puerto Rico or larger in which flowering plants do not literally outweigh the nonflowering. In large islands, like Victoria, they probably outnumber them also in species.

b. It should be remembered, further, that not merely are the volume and weight of flowering plants at any given moment greater than those of the nonflowering, but also that the flowering grow more rapidly.

c. Of the most northerly of the flowering plants, many of which are found within a few hundred yards of the north coasts of the most northerly islands, the following have been cited by various authorities: bluegrass, timothy, goldenrod, dandelion, buttercup, poppy, primrose, anemone, alpine chickweed, purple saxifrage, heather, arnica, ferns, shinleaf, bluebell, rhododendron, cranberry, curlewberry, and cat's-paw.

41. Pink snow.—"Pink snow" (usually *Sparella nivalis*) is found at distances as great as 20 miles from shore, and therefore perhaps at any distance from land. It consists of microscopic plants growing in snowbanks. The coloring of the snow cannot be seen when a little of it is picked up in a spoon or at close range to a snowdrift. But a few yards away, perhaps best at 30 or 40 yards, with the right

slant of the sun, varying shades of pink or even red coloring to the drifts can be seen. The colors blend into each other. Snowbanks reflected in the sky frequently have a pink tinge, caused by the presence of "pink snow."

Section II

GROWTH

42. Grass.—*a.* Grass does not usually grow tall on the Arctic islands. Lieutenant Mecham, however, around 1850, spoke of meadows on Melville Island "resembling English meadows". Melville is well north of the middle of the Canadian Arctic Archipelago.

b. The perpetual light and the considerable warmth may, in the case of some plants at least (among them wheat and tuberoses), produce a growth twice as rapid as that in temperate or tropical climates. Considering the plants as growing during sunlight, this means the same growth per hour in the Tropics and Arctic; the double Arctic growth is due to the double number of hours of sunlight per calendar day.

Section III

USES

43. Greens.—*a.* A considerable use of Arctic vegetation as food or medicine might have been made by explorers during the period when it was believed that scurvy resulted from lack of vegetable elements in the diet. That such use was seldom made was due to the firm but ill-advised confidence which the explorers had in lime juice as a specific. On a few expeditions one form of green vegetation or another was eaten in connection with the lime juice and always with good results. However, the only expeditions which ever were completely free from scurvy were those which had considerable amounts of fresh animal food in their diet. Now that it is understood that complete protection from scurvy is derived from such things as steaks and roasts as easily as from citrus fruits and

onions, some of the motive for eating northern vegetation has been lost. However, the roughage value of greens is still great.

b. The greens that explorers did use against scurvy were most often sorrel, or plants which were thought to resemble it. This was because the antiscorbutic virtue of lime juice was supposed to depend on its acid content. Probably an equal benefit would have been received from eating many nonsour local green things that were succulent enough to be readily swallowed.

44. Berries.—*a*. Berries that are more or less relished by whites and by some Eskimos are found in the Canadian Archipelago as far north as Melville Island, and correspondingly elsewhere. The most northerly of these is the Eskimo *paunrat* (crowberry, *Empetrum nigrum*—Linnaean) which is watery, of little food value, and of no significance as scurvy-preventive to people already on an antiscorbutic diet, though doubtless useful to a party stricken with scurvy from some other diet and unable to get fresh meat.

b. The most northerly berry of significance in the Eskimo economy, and correspondingly available to Europeans, is the salmon berry (cloudberry, *Rubus chamaemarus*—Linnaean). This is yellow in color and somewhat resembles a raspberry, grows in a manner similar to a strawberry, and is found in numerous places well north of the Arctic Circle. It may be in such abundance that patches of ground look yellow at a distance. The berry is agreeable in taste to the average European, delicate rather than pungent in flavor. Salmon berries can be gathered by the bushel and no doubt preserved for winter in any of the ordinary European ways, or they could be frozen by a quick-freezing process. The whalers used to freeze them at Herschel Island by placing them in the natural cold-storage houses where they kept their caribou meat. Moreover, frozen on their stalks, many of them can be found still in position during the winter; and even into early spring they can sometimes be picked. Eskimos—chiefly in western Alaska—preserve them in oil. In some districts, for instance Coronation Gulf, the berries are not eaten either fresh or preserved.

c. At the edge of the woods many of the accustomed temperate-zone berries appear. Currants and cranberries are the chief of these.

d. In the forest area, as in the Yukon, wild strawberries are found and domestic ones may be cultivated.

e. About half of the ordinary berries of the northern United States can be cultivated successfully in districts such as those bordering

the Yukon in Alaska and the Lower MacKenzie well toward the polar sea in Canada. Reports on this subject are available from the United States and Canadian Governments and, more recently, from the Arctic Institute of the U. S. S. R.

45. Edible root.—*a.* One northern root is used extensively and regularly by some Eskimos and in famines or minor emergencies by others. This is a species of knotweed—either *Polygonum bistortum* (Tournefortian) large, *Polygonum viviparum* large, or *Polygonum fugax* small. The root is called by the Eskimos by some variant of the word *masu*. In western Alaska and some other places, large bags of these roots are kept for winter, soaked in oil (usually seal or white-whale oil).

b. The chief objection to *masu* is that it is constipating. Western Alaskans recognize the oil in which *masu* is preserved as counteracting this—they say that *masu* is not good to eat by itself. In Coronation Gulf, where *masu* is seldom eaten except during times of scarcity, there usually is no oil available at the time; so the constipating effect is much feared. The fact that ordinary constipation is rare or unknown among these people makes them the more reluctant to face it in connection with hunger.

46. Plants used for wicks.—It is of use to know what makes a good wick for an Eskimo seal-oil lamp. The best answer is that most anything serves if it is dry and finely shredded or not too finely powdered. Decayed wood, pussy-willow fuz, or moss can be used for the purpose.

47. Fuel.—*a.* As an Arctic prairie fuel, the resinous *Cassiope tetragona* is most valuable. This is a species of white heather, varying in height from 3 to 10 inches. An important element in what might be called polarcraft (by analogy with plainscraft, woodcraft) is learning during the summer to recognize locations where this heather will grow; then, during winter, digging for it at places covered with several feet of snow.

b. Willows tall enough to shelter a camp or for their stems to be of much use as fuel or for house-building are found only on a few of the larger islands, chiefly Victoria Island and Greenland and perhaps also on Jan Mayen.

c. In many of the Arctic islands, the willows are of considerable value for fuel when the roots are taken along with the stems. In many places, even in midwinter, willows can readily be found where the snow has been swept from the tops and slopes of hills. Traveling by sledge, sufficient firewood to cook one or more meals can be secured by gathering the willows en route.

d. On the mainland there are few rivers along which willows do not grow, a half dozen miles or so from the sea. (These willows consist of the true willows as well as alders and other species.)

e. The first tree encountered coming from the north is, in some places, the cottonwood. However, this is of botanical rather than practical interest, for such cottonwood clumps are nearly always small. The first "important" tree is usually the white spruce; next in order is the black spruce, and then cottonwood. After that the number of species increases rapidly.

48. Size of trees at northern limit.—*a.* It was formerly considered that trees became gradually smaller the farther and farther north one went. However, tree growth in the Arctic depends on several factors. In one area the forest belt along a river may be up against a ridge, in whose protection tall and graceful trees grow. Within half a mile up a steep slope the trees end abruptly and beyond there are none. Continuing straight north no trees will be seen until the polar sea has been crossed and a corresponding climatic situation attained in Siberia.

b. Within a dozen miles of the tree line, the white spruce may be found, growing as tall as that species grows even a thousand miles farther south. White spruce 40 feet in height has been reported within 40 yards of the tree line.

CHAPTER 6

SHELTER, HEAT, AND LIGHT

SECTION I

EMERGENCY SHELTERS

49. Snow houses.—A discussion of the construction of snow houses is found in the appendix to FM 31-15.

50. Tents.—*a.* In matters other than winds and their effects, temperate-zone experience and forethought based on it are in the main suitable guides for Arctic camp location. A tent should not be pitched in a lee, for it will collapse when snow buries it. Well before collapse, the snow covering may bring serious results; carbon dioxide gathers through decrease in ventilation so that lamps will not burn and breathing grows difficult; odorless carbon monoxide may gather, from which death may result. Sledges, baggage, or any other large objects should not be left to windward of the camp; for these obstructions will produce their own lee, which forms drifts to and upon the shelter.

b. Types of tents and methods of pitching them are discussed in FM 31-15.

51. Windbreaks.—*a.* Tents pitched on open prairie should have a windbreak of snow blocks. Windbreaks at intermediate distances bury a camp; those far enough or close enough protect it. A distant windbreak is usually beyond available resources. Therefore, a windbreak right up against the tent is more practicable.

b. For a one-night camp, the tent should be protected by a wall of snow or ice blocks forming a segment of a circle to windward of the tent. If material is available, a wall 5 feet high is adequate. Even a wall only 2 feet high is of considerable value for a 7-foot tent. A windbreak can be built in European sod-wall fashion or, if the personnel is sufficiently skilled, it may be built Eskimo style,

curving it in just enough so that the wall segment will follow dome construction procedures. (See FM 31-15.) The windbreak is constructed far enough from the tent so that a man can work comfortably between. The important thing is to protect the bottom and sides of the tent.

c. For permanent camps, or where there are chances of change in wind direction during the night, the windbreak should be built in a circle completely around the tent. To reinforce the windbreak against violent gales, water should be poured over the windbreak wall, provided water is available.

52. Emergency shelters.—For the construction of emergency shelters such as a lean-to, see FM 31-15.

SECTION II

ARCTIC FUEL AND HOW TO USE IT

53. Striking a light.—*a.* Intimately connected with the problem of emergency fuels is the question of emergency ways of striking a light. The best is the use of iron pyrite. Iron pyrite is found on a good many of the Arctic islands and on many parts of the mainland coast.

b. In summer, two chunks of convenient size for handling should be carried on a trip. The standard Eskimo chunk is of about the same shape and dimensions as those of a lemon. For cold-weather use, the chunks should be about two-thirds covered (preferably with rawhide, for that shrinks into snug position after being sewed on).

c. When a fire is to be lighted, any kind of tinder should be spread out, preferably in a place where it can be reached by wind but not by rain or snow. It is best to use a large pad, say the size of an ordinary correspondence envelope. The tinder may be anything that catches fire easily, such as rotten dry wood or pussy-willow fuzz. The

stones are struck together and a shower of sparks falls on the pad, dozens of particles of tinder probably catching fire. If the wind is right, it fans the sparks into a glow. If there is no wind, the sparks must be blown. When sufficient tinder is lighted, it should be removed from the pad and transferred to the vicinity of the dry kindling, where the wind is allowed to blow on it or the one making the fire blows on it.

54. Stoves and fireplaces.—From the wreck of a ship or when the party arrives at the coast something usually will be found available (perhaps gasoline tins) out of which a stove and stovepipe can be constructed. If wood or coal is to be burned, a stove is much better than an open fireplace.

55. Coal.—*a.* Across the entire Arctic from Canada through Siberia coal of satisfactory quality for use (though sometimes scarcely of commercial value) is found in many river valleys. In some creek mouths, pieces of coal-float indicate that there are veins inland. This coal usually lends itself to surface mining and is commonly a fair quality lignite. Occasionally a sort of pitch will be found which can be used for kindling. It burns with a flame similar to that of sealing wax, with a very black smoke and an odor resembling that from warm asphalt. Other coal has much the same appearance as wood compressed into bricks or irregular fragments. On sea beaches in some places, as between Barrow and Icy Cape, coal sometimes is found in windrows. This coal has been scooped from the sea bottom and piled on the beach by ice pressed toward the coast.

b. Starting a coal fire is sometimes difficult. At Grassy, asphalt was found which served for kindling. Wood may be available to start coal fires; or they may be started with animal fat burning on some kind of wick, such as broken-up dried bones or a piece of rag. It may be necessary, if kindling is scarce and coal abundant, to keep fires burning day and night.

56. Wood.—*a.* Occasionally there will be found wood partly turned to coal, reddish in color. Sometimes when burning, this produces an agreeable odor.

b. Driftwood, once piled high on northern beaches, has grown scarcer every year since the custom of burning wood in stoves instead of animal fat in lamps has spread among the natives. In northern Alaska and northwestern Canada, driftwood is usually found in great abundance, though sometime exclusively on westward-facing beaches. This is caused by the fact that low waters occur with easterly winds and high with westerly.

c. Willows and resinous plants have been discussed in chapter 5.

57. Kindling.—When traveling in rainy weather across an Arctic prairie where *cassiope* is the fuel to be used, it is well to carry along kindling or pick up some en route. Heather may be discovered growing in such shelter that it is dry even on a rainy day. It may be picked and carried along, in a dry place, and used for kindling at camp time.

58. Wood and fat.—*a.* It has been found that a piece of half-inch board 3 inches wide and 18 inches long, whittled or split, and burned with one-quarter of a pound of caribou suet is sufficient to cook at one time meat to last three men all day. When meat is cut into pieces about the size of sugar cubes and put on in cold water, it is cooked even before the water boils.

b. Cooking can also be done with the hair and wool of a musk or of a grizzly bear. One hide will probably cook two or three pots holding 8 quarts each.

59. When not to burn fat and hides.—Of course skins should not be burned for warmth or cooking if they are needed for clothes or bedding; nor is animal fat burned if there is a chance of running out of food. It is much better to eat the food raw and to get necessary warmth from food eaten and clothes worn than to burn them for heat. This may seem an unnecessary statement, but members of the Franklin expeditions did continue to use some of their food for fuel even after they were on small rations and getting weak from hunger. Some of them starved to death as a directly traceable result.

60. Seal oil.—The seal furnishes food, clothing, heat, and light. The blubber of the animal is, if anything, even more important than the meat; for it furnishes heat and light as well as food.

61. Outdoor cooking.—Stoves for cooking outdoors with seal oil or blubber have been rigged up by using a cylindrical galvanized sheet-iron tank the sides and bottom of which were clinched and soldered so that it would not come apart when heat was applied. When beginning a trip the tank was filled with kerosene; after this had been used, the top of the tank was removed and a draft hole cut near the bottom; then halfway up the stove two or three heavy wires were run across for the cooking pot to stand on. To be suitable for cooking purposes, these cylindrical tanks should have a diameter a little larger than the largest cooking pots and a height of about 15 inches.

62. Wick.—*a.* In burning seal oil or blubber, as in burning tallow, a wick must be used. Asbestos might serve, since it could be used over and over again; however, the fibers would become so clogged with the incombustible residue of oil that its usefulness as a wick

would be destroyed eventually. Moreover, there is a simpler method. (See *b* below.)

b. (1) Save the clean-picked bones. When next the fire is to be built, use a little piece of rag for kindling, not necessarily more than an inch square, soaked in grease and put on the bottom of the stove. On top of it place a little heap of the bones, and on top of the heap lay several strips of blubber, resembling so many strips of fat bacon. Touch a match to the rag, which will burn like the wick of a candle. The flame plays up between the bones and strikes the blubber. This begins to fry and the oil trickles down on the bones, making a film on their outside. Upon sufficient heating this film blazes up, and thereafter the fire burns with a furious heat so long as strips of blubber continue to be placed upon it.

(2) Now stand the cooking pot, filled with meat and water, upon the cross wires within the stove 6 or 8 inches above the bottom. The flame first strikes the bottom of the pot and then spreads up all around it. This brings the pot to a boil quickly as would the large wood fire.

(3) The disadvantage of this method of cooking is that the smoke of seal oil burned in this manner is thick and black and exceedingly sticky. It is, in fact, the best quality of lampblack and clings to everything. Personnel, equipment, tents and sledges should not be in the path of the smoke. White dogs that lie in the path of the smoke have become nearly black after the cooking of one meal.

63. Eskimo stone lamps.—*a*. These are used both for cooking and for heating; they are large half-moon-shaped bowls that have been adzed or scraped out of blocks of native soapstone. The wick is a ridge of powder, of one of the materials described below, lying along the straight edge of the lamp.

b. Almost anything that is thoroughly dry will serve as a wick for these lamps. Thoroughly decayed soft wood makes a fair, hardwood sawdust an excellent, and softwood sawdust a fairly good wick. The Eskimos sometimes use scraped walrus ivory, dried moss that has been rubbed into powder between the hands, or the fuzz of pussy willow. Occasionally, if other materials are not available, "civilized" Eskimos will take small pieces of manila rope and hack the fibers into lengths of $\frac{1}{20}$ of an inch or less, thus practically converting the fibers into powder. Stefansson reports seeing commercial smoking tobacco used with good results and without causing an appreciable tobacco smell in the house. He once tried using ordinary commercial lampwicks, but they were difficult to keep burning without smoking.

c. For ideal burning, the bowl of the lamp must always be almost full of oil but never quite full. This may be regulated automatically. A slab of polar bear or seal fat is hung almost over the flame. If the oil in the lamp gets a little too low, there is more of the lampwick exposed and the flame becomes larger; the increased heat of the flame fries out the fat hanging over it and makes the oil trickle down more rapidly. This gradually raises the level of the oil in the bowl until it floods part of the wick and decreases in that way the size of the flame. This in turn cools off the air sufficiently so that the slab of blubber stops dripping. Then the flame gradually increases in size as the oil lowers in the lamp until a second flaring-up again brings oil down from the slab of fat.

d. An Eskimo oil lamp that is kept properly trimmed produces no smoke and will burn with regular fluctuations 6 or 8 hours at a time. Ordinarily lamps that are trimmed in the evening are still burning brightly the next morning unless there has been failure to put a large enough piece of blubber on the hook above the lamp.

64. Superiority of imported fuels.—*a*. The foregoing are fuels indigenous to the Arctic and, as indicated, are satisfactory when commercial fuels are not available. When circumstances permit, however, kerosene should be carried. Hauling fuel on the trip is more important than hauling food and the kind of fuel is more important than the kind of food. Better light and more convenient heat are derived from kerosene burned in lamps and in blue-flame stoves than are to be had from seal blubber burned by any method so far devised.

b. Kerosene lamps and stoves are not described, for better ones designed for travel use are constantly being invented and developed.

Chapter 7

FOOD AND DRINK

Section I

SPECIAL METHODS

65. General.—This chapter discusses special methods and special foods for cold-weather operations. (See also FM 31–15.)

66. Care of food.—*a.* There are not many foods spoiled by cold, or at least not materially. Potatoes, which have been frozen and are kept in that state are almost as good as if they had not been frozen. The same is true of eggs, apples, and the like. Meats are so little affected that it takes discrimination, if not expert judgment, to tell the difference between those that have and those that have not been frozen.

b. Under permanent conditions of thaw, or conditions of intermittent thawing and freezing, careful packing is required; under permanent frost very little care is required. Milk can be frozen into bricks and handled like bricks. Meat can be cut into separate steaks or roasts before freezing and then handled like chunks of wood. Meat can be carried if desirable as an entire ham or even a carcass. Then, when meals are to be cooked, pieces can be cut with saws or axes. Saws are generally better, for with intense cold an axe will splinter meat and some of the splinters may be lost. Sawing does, of course, waste a bit of the meat if care is not exercised; but sawdust can always be gathered and saved.

c. All foods can be carried frozen and handled with freedom except those that are greasy. Even greases freeze "clean" when it is cold enough. Some of them, like tallow, may be handled freely without much staining of mittens at temperatures only a little below freezing. Butter is clean to handle at zero. Lard will not grease much at

temperatures of 20° or 30° F. below zero. At 50° F. below zero any fat can be handled in chunks except a few of the oils, such as whale and seal. These are in a semiliquid state.

d. A food much carried in the north is baked beans. They are often frozen into bricks. However, they are more convenient if baked dry and frozen into separate kernels so that they can be handled like peanuts. For warming the beans, whether in bricks or separate, a little water or grease should be placed in the cooking receptacle.

67. How to cook food.—*a.* If fuel is likely to be scarce, uncooked foods will probably prove unsatisfactory. If fuel and time are expected to be plentiful, naturally uncooked things like beans and rice may be carried. Beans are among the slowest things to cook, requiring leisure and much fuel. Rice and oatmeal can be prepared with a minimum. If snow water is to be used for the liquid, put the beans on top of the snow in the pot; if cracked ice is to be the source of liquid, place them on top of the ice. In order to prevent burning, care must be taken to see that cereals and foods of that sort are not on the bottom of the pot before the snow or ice begins to melt.

b. If cereals are in the pot when the snow is being melted or are put in with the cold water, and if the fire is slow, as that of a seal-oil lamp will be, then the cereal is nearly cooked when the water comes to a boil. When rice was to be cooked on the Stefansson expedition it was standard practice to take the pot off the fire one or two minutes after it came to a boil and to stand it on a piece of wood or other nonconductor wrapped in a blanket or placed under a skin—a fireless cooker effect. Twenty or thirty minutes later the rice would be adequately cooked. Oatmeal cooks still more easily.

c. A good way to use beans, peas, or lentils is to have them ground up into coarse flour. They cook, then, with hardly more difficulty or time than oatmeal.

Section II

SPECIAL FOODS

68. Fat in diet.—Fat is the most important ingredient of an Arctic ration. It is, in calories, the most condensed of foods. An ounce of fat (butter, bacon fat, tallow) is more than twice as nourishing in the caloric sense as an ounce of sugar or an ounce of dried lean. If portability of a ration is being considered, it is then essential

that it shall contain as much fat as the consumer can take without beginning to turn against it; the rest of his food requirements will be supplied from other sources. It is considered that the human body cannot repair itself without protein. Theoretically, then, the ideal condensed or portable ratio is as much fat as is needed for calories and as much protein as is needed for body repair.

69. Emergency food.—*a*. Pemmican is an ideal emergency food for a journey up to 6 weeks; after which it will have to be supplemented by other foods, or else vitamin C will have to be supplied as a drug, probably in capsule form.

b. Both the word and the idea "pemmican" are from Indian sources. The essential ingredients are the two chief components of meat, lean and fat.

c. The danger of too much lean against fat in pemmican is not solely one of faulty economy. If the excess of lean over fat is sufficiently marked, the men eating it may develop protein poisoning—nephritis. This was undoubtedly the cause of at least one death in the Bartlett party of the third Stefansson expedition.

d. What is probably a good standard for pemmican was determined at the Russell Sage Institute of Pathology of New York when Stefansson and Anderson lived a year exclusively on meat and water. It proved that on the average their requirements were supplied by about 1⅓ pounds of lean and ½ pound of fat. No salt is necessary. (See FM 31-15.)

70. Chocolate and rice good condensed rations.—*a*. Although not nearly as rich in calories, pound for pound, as pemmican, chocolate is usually looked upon as good condensed rations. Rice is another. On the third Stefansson expedition, where fuel did not have to be economized, it was secured along the way by killing seals. One of the favorite foods was a stew made by boiling rice in water to which were added chocolate and lumps of chopped-up suet—in that instance caribou fat.

b. Peary never got full satisfaction from men working hard when they were fed less than 2 pounds per day of his pemmican-biscuit-tea-sugar ration; the Stefansson party got results which appeared to be satisfactory, at least for a week or two at a time, from something like half a pound of rice, half a pound of suet and a quarter pound of chocolate.

71. Dried fish.—For men and dogs, dried fish is a good as well as a cheap ration. Along the Yukon River and elsewhere in Alaska dried salmon are put up by the ton; and an expedition planning to go into the sea north of Alaska could, especially by a year's

advance arrangement, secure great quantities of this excellent food. It needs no preservative even on a ship's deck; it requires protection against sea water and rain. The Stefansson experience was that the men became very fond of these dried salmon. The salmon, dried native style, are not salted.

Section III

LIVING OFF COUNTRY

72. Food sources.—In much of the Arctic about the only food to be secured "off the country" is derived from animals. (See chapter 5 for Arctic vegetable sources.) The major part of this chapter is therefore devoted to a discussion of meat diet. Only the types of meat that are likely to be secured in the north, with preferences as to parts of the animals and to cooking methods, are considered.

73. Milk.—No northern wild animal gives a large amount of milk, not even the huge moose. Domestic cattle, when allowed to run wild on the range, give only from 3 to 5 pints of milk; whereas, the same cow would give four times that much under dairying conditions. Musk oxen give a surprisingly large amount, the flavor of which is about like that from the Jersey cow, though somewhat richer, for the "whole milk" is about the consistency of commercial light cream. Probably the percentage of fat in the undiluted milk is not as high as in dairy cream, but the consistency does give a creamlike impression.

74. Favorite northern meats.—The usual view of northern meat-eaters is that caribou provides the best meat of the land animals while the seal provides the best of the sea animals. White newcomers are likely to prefer the musk ox because it is practically identical with beef.

75. Musk oxen.—*a*. Some travelers have stated that the flesh of musk oxen is strong—that it tastes of musk, from which the animal is supposed to have received its name. Observers who have lived on these animals for long periods say, however, that the strong taste is found chiefly in old males and that it is no stronger than the corresponding taste in old seals, old caribou, or old domestic sheep.

b. Peary said that musk ox was better than domestic beef, but he probably meant only that his appetite was better when he was eating it since the two seem almost indistinguishable. In color and flavor, the fat of the musk ox is similar to that of beef, though not practically identical as is the case with the lean. Stefansson's companions agreed they preferred musk-ox fat to beef fat; they further agreed that there is a greater range of flavors as between fats from different parts of the body. The largest accumulation of fat is on the neck, and this is especially delicious.

76. Polar bear.—Europeans commonly like the taste of bear meat, saying it is like pork. But it is stringy, gets between the teeth, and makes the gums sore. After eating bear for a week or two, one is likely to begin cutting it in small pieces and swallowing these without thoroughly chewing the pieces. This applies to cooked meat, not to raw. Cooking increases toughness and brings out the stringiness. Chewing frozen raw bear meat is like chewing raw oysters; half-frozen, it has, like other raw meats, the consistency of hard ice cream. After some experiments by Stefansson, he came to the conclusion that certain polar-bear livers may be slightly poisonous while others are not.

77. Seals.—There is little preference between parts of the seal. Most people like the liver boiled, or frozen and raw. The heart and the kidneys provide good dishes.

78. Caribou.—With caribou, the other great food animal of the north, there is a scale of choices and there are marked preferences. The best parts are the head, brisket, ribs, backbone, and pelvis, in that order. The brisket is too fat at certain times of the year. To overcome this, much of the fat and nearly all of the lean is peeled away before boiling the bones. Ribs are seldom considered too fat, but some of the ribs have too much meat on them, which is removed before cooking. Similarly, a considerable part of the meat is cut from the backbone before cooking.

79. Rabbit starvation.—If transferred suddenly from a diet normal in fat to one consisting wholly of rabbit, bigger and bigger meals are eaten for the first few days, until at the end of about a week three or four times as much is being consumed as at the beginning

of the week. By that time there are signs of starvation and of protein poisoning. Numerous meals are eaten and hunger is felt at the end of each; distention of the stomach with much food causes discomfort, and a vague restlessness begins to be felt. Diarrhea will start in from a week to 10 days and will not be relieved unless fat is added to the diet. Death will result after several weeks.

80. Arctic birds.—Some Arctic birds are well supplied with fat, but only those that migrate. Geese and ducks are fat in the spring and never quite without fat during the summer, fattening again somewhat in the autumn. Swans have a good deal of fat, but cranes do not. By common northern opinion, Eskimo and white, the owl is one of the best of the food birds but has inadequate fat. Ravens are not considered good because they are skinny. The ptarmigan has little fat. The owl, the raven, and the ptarmigan are the chief birds that spend the whole year in the farthest north. Some species do go south but many remain in the north.

81. Fish.—On the average, fish have enough fat in them for food but little or nothing over for lighting, cooking, and heating purposes. A thing known to some Europeans is commonplace in the north, that cod liver is the most delicious form of fat. The greatest of all delicacies is the liver of the fresh-water cod, the ling. These livers are eaten boiled.

82. Skin clothing and boats in case of starvation.—In discussions of skin boats and skin clothing it has been pointed out that all articles made of rawhide or hide not commercially tanned can be used for food. They have considerable food value, and there is no substance in them that tends to cause illness.

83. Cooking methods.—*a*. The easiest method of cooking is boiling. On shore or at sea, fresh water is to be had for cooking in summer and autumn—on shore this is from lakes and rivers, and at sea it is from rain or thaw water on top of the ice. But in winter, sometimes on land and always at sea, snow and ice must be used. Typically, cooking is begun with a pot three-quarters full of cracked ice; on top of the ice, chunks of meat are piled, a few of them as small as a closed fist but the average size perhaps that of both fists held together—except of course the parts which are thin, such as ribs. As the ice melts the meat sinks. While the water is gradually warming, the meat thaws. When the pot comes to a boil, or perhaps 2 to 5 minutes later, it should be taken off the fire and set on some nonconductor such as a piece of wood for the cooking to proceed fireless-cooker style.

b. The reason for taking the meat off as soon as it comes to a boil

may be any one of several or a combination of them. Fuel can be conserved; warmth for the room may be needed, in which case it is desirable to have the heat direct and dry rather than indirect by way of steam from the boiling pot; the chief reason, perhaps, is avoidance of the steam nuisance to prevent condensation on the roof of a tent and subsequent dripping on bedding. Furthermore, the meat will be adequately cooked.

c. A typical roast is well done only for a small fraction on the outside; inside there is a layer that is medium done; and innermost the meat is rare. This practice has developed, no doubt, in response to taste or perhaps instinct. Oxidation destroys or weakens vitamin C in those outer layers of the meat which are well or overcooked. There is little oxidation on the middle layers and practically none on the raw (rare) central portion. Therefore, there is always protection from scurvy so long as meat is cooked in approved Eskimo fashion.

d. Meat-eaters do not, properly speaking, have soups; but it is customary with some of them that when meat has been boiled it is removed from the broth and then a little blood is poured in, the whole being stirred meantime. This produces, with the right proportions, a broth of the consistency of pea soup.

e. Frying, besides being a method of cooking unknown to most if not all "native" races, is least likely to be convenient. If it is convenient and fried foods are desired, there is no argument against it. Whites, no matter how long they have been on meat, may desire fried liver. However, the general preference, growing stronger with the years, is for liver either boiled or frozen raw. Generally, as explained elsewhere, only seal livers are used as human food—caribou liver is usually dog feed, and bear liver is thrown away.

84. Fish.—Boiling is the preferred cooking method for fish. The chief exceptions are for dried fish.

85. Preservation of food.—*a.* If animals are properly butchered, the meat without cover is perfect after 6 or 8 months of winter except that it may develop a sort of skin by drying on the outside if it is exposed to the air. If it is buried this skin does not develop. Beans baked with pork will similarly be perfect for several months, although a slightly rancid taste may eventually develop in the pork. Beans baked with fresh seal or whale fat turn rancid in a few days or weeks. The sea mammal fats become rancid even at the lowest temperatures if air gets to them.

b. Meat can be stored in underground chambers for years provided that certain molds which flourish at ground temperatures down to

20° below freezing are prevented. If these molds get into a storehouse, it necessitates emptying of meat and destruction of mold either chemically or by peeling an inch or two of earth from floor, walls, and ceiling.

c. If an animal is buried so that the body is protected from air, at average Arctic ground temperatures (from 0° to 10° F.), the flesh remains practically unspoiled for thousands and perhaps tens of thousands of years, as has been shown by the remains of the now extinct mammoths which have been uncovered in the Arctic.

d. The best food preservative known, frost, is also indirectly valuable; for instance, if fish or meat is to be dried in summer, maggots must be kept out of it. If the season is rainy, it may be difficult or impossible to produce good dried meat or dried fish beyond what facilities can be managed for smoke-drying. In winter, however, there is no trouble, although drying then is very slow. It is said to take about a week in calm air at 50° below zero to dry a wet cotton handkerchief. But several months before spring, meat may be split into thick pieces and spread on anything—on the snow, on a piece of wood, on stones—and it will be dry before spring, with no possibility of contamination. However, even in cold weather, seal, walrus, and whale blubbers become rancid when exposed to the air. Therefore, care must be exercised to remove all fat from any pieces of these meats which are to be dried.

Section IV

SOURCES OF WATER

86. At sea.—*a.* At sea far from land the experienced Arctic traveler uses last year's ice, or older, for drinking and cooking. It can be distinguished from the current year's by the rounded corners which are due to the rains and thaws of one or more summers, by a bluish look in comparison with salt ice which is grayer, and by producing glare; salt ice is milky in appearance. Ice of last year rarely has noticeable saltiness; ice which is 2 years old is probably fresher than average river or spring water.

b. In summer there is always a certainty of obtaining perfectly fresh water at sea from the hollows in old ice—unless the pond used is so near the edge that spray has dashed into it. Even on this year's ice which itself is salty in midsummer, water plenty fresh for drinking may be found.

87. On land.—*a.* On land the Arctic winter traveler will by preference chisel through the surface of a lake or river till he gets fresh water. It saves a lot of time at camp, and it is a convenience when traveling. Under many conditions it may be preferable to melt ice or snow.

b. It is perfectly safe to eat snow when thirsty, but most travelers find it more pleasant to drink water. If no water is obtainable, snow or cracked ice is eaten during the day to quench thirst and at camp time chunks of ice are cut up and melted as needed. Eating snow in large quantities chills the stomach and materially reduces the body temperature.

c. There are places where fresh water or fresh ice is not obtainable. Usually these places are on a coast where the ice to seaward is solid and where there is perhaps brackish water in a lagoon on the landside. In this case granular snow is used. The more granular the snow the greater its water content per cubic unit of snow block. The best snow of all is so granular that it will not even cut into blocks. This snow is brought to the house in buckets or wrapped in cloth or skins.

d. During the summer there are innumerable sources of pure fresh water. It is in very few parts of the Arctic, and only in mountains, where lakes are likely to be more than a few miles apart. In the mountains rivers or rivulets are numerous though lakes are few.

88. Melting snow.—*a.* There is no trouble about using new, spongy snow except that a lot of bulk makes very little water and also, because of the air chambers, it takes a little more fuel to do the melting.

b. If the snow is extremely spongy and a hot fire is under the pot, the snow will suck up, blotter fashion, the water which forms immediately over the flame, leaving a cavity which permits the flame to play for awhile on metal which has no liquid on the inner side of the pot. This is not dangerous with ordinary cooking utensils; but trouble will result if using, as Peary sometimes did, a 5-gallon kerosene can for a kettle. In that case the heat may spread to the corners where they are soldered, melting the solder and ruining the pot.

c. When melting very spongy snow over a very hot flame it is advisable to put only a small amount of snow into the pot at first, just covering the bottom. As melting occurs, more snow is whittled into the pot. After a quarter inch or so of water has been melted in the pot, the snow may then be added in chunks if they are not too large. Only after several inches of water are in the pot is it safe to fill it to the rim with the spongy snow.

CHAPTER 8

CLOTHING AND PERSONAL EQUIPMENT

SECTION I

GENERAL

89. General.—*a.* As protection against the weather of their various seasons, the Eskimos have developed on the whole better garments than probably any other people in history.

b. Complete winter dress of reindeer (caribou) skin, Eskimo style, including all garments, inner and outer from head to heel, weighs less than 10 pounds. There are various degrees of softness in the garments according to the age of the animals; but in general, every garment except the boots is as pliable as velvet. The wearer of these garments can sit outdoors at $-50°$ F. and be practically unaware of the temperature, if no wind is blowing. It is commonplace, for instance, even with whites who have never worn such clothes before, to be so comfortable that, quite naturally, they will take off their mittens, pull out a pipe, light up and smoke, with no thought as to whether they are doing it in cold or warm weather.

90. Eskimo clothes.—*a.* When typically dressed for cold weather in Eskimo clothes, an Arctic traveler wears fawnskin undergarments with the fur turned in—socks, drawers, shirt, and mittens. The outer garments—trousers, coat, boots, mittens—are made with the fur turned out, except that the hair side is turned in on boot soles always and on the palms of mittens usually. The coat goes over the head like a sweater and has no buttons or anything of the sort at the neck.

b. Since one of the advantages of the Eskimo-style coat is its loose tailoring, there can hardly be much advantage in using a zipper fastener for nothing can be taken off more easily than the properly designed coat. There is the slight advantage that when the wearer

is overheated he can open up the front of the coat; but most people used to the Eskimo garment will prefer to take it off entirely, for a 2-pound fawnskin undershirt will give sufficient warmth at the lowest calm-weather temperatures, while the wearer is walking or otherwise exercising.

c. The hood of the coat should not come close around the face. The typical Eskimo-style hood merely covers the ears and leaves the whole forward half of the head unprotected. The first "improvement" that a white man usually tries to make is that of having the hood fit snugly about the face. The result, if the hood comes out to the cheekbones and to the point of the chin, is that a circle of hoarfrost forms on the face along the edge of the trimming of the hood and presently the skin under the hoarfrost ring begins to freeze—or, at least, there is a tendency that way. If the face is completely bare, there is sufficient distance between the nose or mouth and the trimming that the breath, in very cold weather, freezes in the air on its way to the trimming and settles upon it in the form of hoarfrost which is dry and can be brushed off.

d. An important feature of the Eskimo coat and shirt is that the sleeve is cut more like a trouser leg so that the arm can be slipped inside the coat. Then, if one hand gets cold, it is only necessary to pull that arm out of the sleeve and tuck the empty sleeve in the belt, carrying bare hand against bare breast. If it is necessary to sleep outdoors without shelter, both arms should be removed from the sleeves and held against the breast in sleep. All possible body warmth is then imprisoned inside the garments.

e. Both the shirt and outer coat are made so that they hang loosely outside the trousers and come down about halfway to the knee.

91. Improvements for Eskimo clothing.—Outside the furs, snow pants and snow shirt may be worn. These are made of drilling or of some light windproof cloth such as burberry. A "filled" silk or other filled cloth should not be used as it will become stiff in the cold and the filling will crumble out where the garment wrinkles. These snow clothes combined should not weigh more than a pound. On a stormy day they keep the snow from being beaten by the wind into the roots of the hair of the outer furs. Also, they contribute materially to warmth; for to the extent that they are windproof they imprison air, and air is the nonconductor upon which humans chiefly rely for conserving body heat.

92. Water boots unexcelled.—It is, however, only the winter clothes of the Eskimos that are near perfection. For the rains and heat of summer they are on the whole not so well clad as the white

man. Still, there is no invention of the white man that approaches their water boots. The sole, though stiff and durable, weighs only an ounce or two; the upper to the knee is as thin and soft as the arm of a woman's evening glove. Yet they are practically as waterproof—the sole, the seams, and the legs—as if they were of heavy, seamless, commercial rubber.

Section II

SKINS FOR CLOTHING

93. General.—The discussion covers skins which are obtainable in the Arctic and sub-Arctic, whether by purchase from natives or secured by hunting.

94. Polar bear.—The skin of the polar bear is used of necessity in some parts of the Arctic and by choice elsewhere. For rough use, trousers of the skin, with the hair out, are perhaps about the best possible. They are not warm for the weight, but they are strong (will last many years if properly cared for), they shed snow, or rather snow beats out of them easily, and they are to an extent waterproof—what would be called showerproof if they were being advertised by a dealer. They are made knee-length and almost necessarily so, for long trousers of this material would not bend easily enough to permit free movement of the legs.

95. Fox.—A coat or shirt of fox, either blue or white, is certainly very warm for the weight; but, while the hair wears longer than that of caribou, the skin is so fragile that the clothes need meticulous care. The fur mats, does not stand wetting, and gathers snow. Fox skins

are much used by the Cape York Eskimos, probably because caribou is scarce. However, since they are much used, the people know exactly how to handle them; and they like these skins because they are used to them.

96. Wolf.—Wolf is stronger than fox, and garments made of wolf are nearly as warm as fox for their weight. The objections are the same as to fox—the matting, the sogginess when they are wet, and the difficulty of beating snow out of them.

97. Wolverine.—Wolverine is used chiefly as a trimming material by the Eskimos who have access to the skins of these animals. Hoods are often edged with a band of wolverine fur. The skins are strong and may be about as good as domestic dog for clothing. But northern people have no experience with this, for wolverine is too costly.

98. Beaver.—Beaver makes a very good coat. The natives use it unplucked, for the long hairs aid in keeping snow from caking and they shed rain to some extent. A beaver coat will last three or four times as long as caribou, but it is heavy and not warm for its weight.

99. Muskrat.—Muskrat coats are between good and medium in desirability. They are stronger than rabbit (see par. 101). If there are skins enough for two coats, it would be better to make one out of the bellies and the other out of the backs than to make each coat out of whole skins. The hair is longer on the backs, and the skin is stronger. Thus, the belly skins would be used for a shirt and the backs for an outside coat.

100. Squirrel.—The fur of the Arctic squirrel, or marmot, has about the same qualities as muskrat.

101. Hare.—The skin of the polar hare is so fragile (that of the bush rabbit still more so) that it is to be used only when better skins cannot be obtained. Still, it makes very good slippers, not next to the foot but between the first and third layers of footgear. Hare can be used for a shirt if handled very carefully.

102. Other furs.—Coats and other garments may be made out of almost any of the other fur-bearing animals, such as otter, marten, and mink. It is most unlikely that marten or mink would be used because of their commercial value; and such skins would, except in dire necessity, be saved for their market value.

103. Birds.—The feathered breasts of certain birds, among them loons and some ducks as well as sea birds, make very good slippers to use like hare-skin slippers—they are warmer and last longer than hare. Coats are sometimes made of bird skins, but only by those Eskimos who are forced by circumstances to do so.

104. Caribou.—*a.* Caribou is the best of all native Arctic materials for winter clothes, so this skin is discussed more in detail than others.

b. Underwear—shirts and drawers—should be made from the skin of calves from a few weeks to a few months old or yearling females killed before September. Eskimos like underwear of newborn and even unborn fawn, but unborn or very young fawn is so delicate that it should not be chosen until the wearer has had considerable experience in the use of sturdier fur underwear.

c. For outer garments—coats and trousers—there would be used fawn from 4 to 6 months old or yearlings, male or female, killed between early July and early September, according to the location in the Arctic. The earlier the spring the earlier the month in which skins are best for clothing. If they are later than September, they are even warmer, pound for pound; the chief reason they are not favored is that the hair is then getting brittle. October-to-December skins are almost too warm for ordinary use; in spite of the coats' shedding, it may be desirable to use them for travel in a sleigh or in the open cockpit of an airplane. The reasons for the increased warmth per pound are these: As the season advances, the skin, which is the heavier part but not so warmth-giving, grows thinner; while the hair, the chiefly insulating portion, but very light, grows longer.

d. For inner mittens the summer skin of yearlings should be used, though fawn is good for light work and hands that do not perspire freely. The hair is turned inside for the entire hand. Outer mittens should be of the leg skins of yearling or 2-year-old caribou; the hair is outside except on the palm and on the inner side of the thumb.

e. Socks, with the fur turned in, should usually be of summer yearling. Slippers to wear outside the innermost socks may be of fawn skin. They may be of hare, bird, or other skin; but (in this one case in the entire suit) blanketing (duffle) is probably an improvement over any skin.

f. A boot much in favor is of caribou leg; it comes to just below the knee (as does the sock) where it fastens with a drawstring. Usually the breeches are something like 2 inches more than knee length and are tucked into the top of the boot which grips them by means of the drawstring. Some Eskimos prefer to have no drawstring in the boot, having it in the breeches instead, the breeches then coming outside the boots. The sole, shoepack-type as always, is of August or September bull caribou from the back skin. October hides are sometimes used, but the skins get thinner as the season advances, so that in October they are not quite as strong. An August

or early-September boot sole is so durable that on snow exclusively, or on snow and grassland, one pair of soles will last at least a thousand miles. However, a second pair is needed for change in order to keep dry and to prevent the hair from falling out.

g. If occasional sea travel is expected, where there is slush on top of the young ice, a boot as described is needed, except that the sole is bearded seal (ugrug) or beluga (white whale). In emergency the skin of a small seal might be used, but it would not keep its shape, be strong enough, or be really waterproof against brine. It might be necessary to use walrus. Walrus would not keep its shape as well as bearded seal or beluga, but it is considered fairly good if the soles are cut from a skin that has been used a season in the cover of an umiak—the large Eskimo boat.

h. If a sole of sealskin instead of caribou is used, it will be necessary to wear more footgear inside. Normally, for a boot wholly of caribou, the entire foot equipment is in two pieces, only the boot itself and a sock of yearling skin. With a seal sole there should be between the sock and the boot at least two pairs of slippers—preferably, the outer of these should be of blanket and the inner of fawn or yearling skin. The outermost blanket slipper is advocated both to take up any brine that may enter (possible especially if the sole is from the small seal and to take up moisture which forms from the condensation of the invisible perspiration (discussed later in this chapter) of the foot against the sole leather.

105. Mountain sheep.—The nearest competitor to caribou among the native Arctic animals in the value of their skins is the mountain sheep. The warmth-to-weight ratio may be even more favorable than that for the best caribou. However, the skins will then not be quite so durable; nor is it quite so easy to beat snow out of them. The preparation and care are the same as with caribou, except that the care is somewhat more difficult.

106. Seal.—*a.* Seal is the most used skin in the whole Eskimo world, but in many cases this is from necessity rather than choice. For certain things, however, the skin of the small hair seal (several species) is unsurpassed.

b. Raincoats are usually made of other materials, but sometimes they are of seal. If the garment is solely a raincoat, the tanning is the same as for water boots. A seal coat with the hair out and not specially prepared is merely showerproof.

c. The hair seal is not suitable for underwear at any season. For an outer coat with the hair out, the skin is good for weather that is not extremely cold. This garment has less warmth for its weight

than any so far described; but it makes up for this partly by being the strongest of all materials, by being water-resisting, by the ease with which it sheds snow, and because it stands most kinds of rough treatment better than any other skin. This includes getting wet and staying wet, although no skin is really proof against much of that—the hair of all of them begins to drop off.

d. For trousers, worn hair out, the seal has the same advantages and disadvantages as for a coat.

e. A very good all-round winter boot is made of sealskin, with the leg of the boot worn with the hair out. The sole may be of bearded seal or beluga. If the sole is of bearded seal, it may or may not have hair against the foot, usually not; if whale is used, there is no hair. If all materials are available, this is the type usually chosen by hunters who are often at sea and frequently have to deal with the slush on young ice.

f. An ideal summer water boot consists of a sole made from a piece of bearded sealskin that has been in use for 1 or 2 years as part of an umiak cover, while the upper is made from the skin of one of the smaller species of the small seals—in northern Alaska and northwest Canada the *phoca hispida.* This is black or dark brown in color, having been prepared merely by removing blubber and hair (as described later) and then by simple drying. Substitutes for the bearded seal sole, are, in descending order, white whale, walrus, and the skin of a very old male of one of the small seal species. In emergency the hide of the back of the neck of a full-grown caribou bull or some thick part of musk ox hide may be used. With the last two, greasing is required, for those skins are more porous.

107. Fur seal.—A commercial skin worth considering for winter clothing is that of the fur seal. Its advantages and disadvantages are probably about the same as those of beaver. (See par. 98.) Like beaver, it should be used unplucked.

108. Domestic sheep.—*a.* Doubtless the most important southern competitor of the reindeer (caribou) in northern clothing is the domestic sheep. The advantages are abundance of supply, cheapness, durability, and comparative resistance to grease. This last-named quality makes clothing made of sheep hide especially suitable for wear by mechanics. The chief disadvantage is that a sheep is not nearly as warm as caribou for its weight. A further disadvantage, until better tanning processes are developed, is that sheepskin stiffens in cold weather.

b. Since lightness and pliability are not very important except for those who have to walk long distances, it would seem likely that

in the beginning at least, most skin clothes used by the Army for Arctic and sub-Arctic work will be made of sheep.

109. Commercial boots.—For certain kinds of rough work, as around mines or in digging ditches, commercial water boots have been found to be better than the Eskimo type.

SECTION III

PROTECTION FROM VISIBLE AND INVISIBLE PERSPIRATION

110. Statement of problem.—*a.* The problem and technique of how to keep winter clothes dry arise from the fact that there always is an "invisible perspiration" from the human body—a vapor invisible at ordinary temperatures but visible even around $-30°$ or $-40°$ F., becoming more conspicuous as temperatures drop toward $-70°$, $-80°$, and $-90°$ F. At $-50°$ F. or colder, from a dry hand there will be seen a cloud of steam rising from the palm and wisps of steam from the fingers. Added to this, as a source of moisture, is of course the ordinary visible perspiration caused by exertion and too-warn clothing. The combined moisture of the two perspirations condenses somewhere in the garments in the form of hoarfrost.

b. In cold weather the dew point, or point of condensation, is reached in the second or third layer of clothing where the cold from the outside meets the warm "steam" and turns it into hoarfrost. If only two layers of clothing are worn, it may be at $-20°$ F. that the dew point is reached outside of the second layer and that all frost will either float away on the air as a fog or gather exclusively on the outside of the outer garments where most of it can be brushed off. But if the temperature drops another 20° or 30° F., the condensation will begin to take place between the two layers. Then, unless necessary precautions are taken, there will be a melting if the temperature later moderates, or in the warmth of a camp. Later, on being exposed to the cold, the dampness turns to ice.

111. Procedure in camp.—*a.* When the shelter is erected, floor clothes, evergreen boughs, small brush, grass or any other available material is placed on the floor; then one man goes inside, and the sleeping bags are handed to him after all snow has been removed from them. He places the sleeping bags according to a prearranged plan. This one man stands in the low part of the shelter in front

of the sleeping bags and takes off his outer garments. He gives each a good shake as he takes it off. If the garment is not to be dried out while in camp, he will place it on the floor. No amount of hoarfrost or snow will make a garment wet unless it melts. There may be a little hoarfrost on the outside of the one layer of clothes, and this can be brushed off.

b. This individual has entered a shelter which is cold and which he later warms up with a fire. The other members of the party enter the shelter which is already warm. They take off their outer clothes either outdoors or in the alleyway, beating off all the hoarfrost and snow. These clothes are handled carefully if they are brought into the shelter, or they should be shaken casually if they are left in the alleyway.

c. The frost can be removed from the hair side by beating with a stick. The frost on the skin side of a garment is usually removed by scraping with a knife. A whisk broom is best for removing frost and snow from snow coats and trousers. A little hoarfrost may remain in the outer garments. The best thing is to see that the garment does not thaw out during the night.

d. For sleeping bags, see paragraph 33 of FM 31–15.

112. Procedure when traveling.—*a*. While traveling, it is best to keep the formation of hoarfrost in the clothes to a minimum by preventing the ordinary visible perspiration that results from physical activity and warm clothing. The method as practiced by Stefansson and his men during thousands of miles of travel in cold weather is one of regulation of temperature by adjustment of clothing. On a very cold morning, when breaking camp, the traveler will wear the full outfit of three layers, except that occasionally a man will work with one or both hands bare for a few minutes at a time, the mittens, or the one not in use, hanging by a string that passes over his shoulders.

b. As explained earlier, the coat and shirt are not tucked into the top of the trousers; they hang loose except that they are kept in at the waist by a belt which probably is outside the outer fur coat, leaving the snow shirt unrestrained. The shirt, coat, and snow shirt come about halfway to the knee.

c. On the road, after half an hour of rapid movement, the traveler begins to feel too warm no matter how cold the weather. The first adjustment for coolness, and to prevent wetting by perspiration, will be to remove the belt so that a certain amount of chill can come up around the body, naked from the waist. So far as this chill comes up, it is agreeable; but it does not come up much because cold air is heavier than warm air.

d. The coat and shirt are loose at the neck. Therefore, the next cooling step may be to pull the coat forward at the neck to make an air channel all the way down from the throat. Cold air will then begin to flow down over the front of the body, which again feels most agreeable if the traveler is overheated. By now the traveler is probably walking barehanded, both mittens hanging suspended by their cord.

e. On growing still warmer, stop the sledge and take off the outer skin pants, wearing now just the drawers and snow pants. The next step (not necessitating a stop since this can be managed while walking) is to remove the outer skin coat, wearing now the shirt and snow shirt. If this is a little cool, as it may be, put on the belt again.

f. If this is too warm, take off the snow pants and snow shirt, walking in the underwear only. Even at −40° and −50° F., with no wind blowing, the traveler may wear nothing but underwear much of the day, putting on outer clothing when stopping to rest or to make camp.

g. There are several reasons why foot protection must never be decreased. Feet are particularly liable to freeze; and freezing of the feet is particularly serious. It can always be determined when any other part of the body approaches the freezing point, but it may not be easy to tell about the feet because they are so encased. It is particularly serious to lose foot garments which have been taken off, since they are much more difficult to replace than other garments.

Chapter 9

FIRST AID

113. General.—First aid is covered in FM 21–10 and 31–15.

114. Monoxide poisoning.—*a.* Among all the dangers of Arctic operations, the danger of suffocation by carbon monoxide ranks as one of the foremost. To people coming to the Arctic regions for the first time, the inconvenience of cold is so great that common sense is often sacrificed to the urge to keep warm.

b. To a person from a tree country, for instance, the logical place to pitch camp is in the lee of a hill. Experience, however, has shown that in the Arctic the dangers of snow drifting over such a camp in the course of the night are very great. Drifting snow may cover the traveler's tent in the course of the night and thus cut off the normal ventilation through the fabric of the tent. Since it is customary to maintain a small fire or stove in operation through the night, the carbon monoxide generated, having no exit, will overcome the sleeping person without warning.

c. Although nearly everyone is familiar with the dangers of asphyxiation in automobiles and closed rooms, few realize that these same dangers are present in the Arctic; therefore, a basic rule to follow is: *Insure proper ventilation.*

d. A common fallacy concerning monoxide poisoning is to the effect that one is warned by fumes. *Carbon-monoxide gas is odorless.*

e. Carbon monoxide combines with the haemoglobin of the blood stream and destroys the efficiency of that fluid as an oxygen-carrying medium; suffocation occurs without warning.

f. If the person is awake he will, in general, suddenly fall over without warning.

g. In an Arctic camp, upon the appearance of carbon monoxide poisoning, the following rules should be observed:

(1) Remove the cause. In case of a stove, turn it off.

(2) Go outdoors, moving slowly. Crawl if necessary.

(3) If some occupants cannot walk out of their own accord, secure proper ventilation immediately and keep them quiet.

(4) Breathe evenly and avoid exertion.

(5) It is important, once outside, not to succumb to freezing. As soon as possible after gaining the outdoors, get into a sleeping bag for warmth.

Chapter 10

EMERGENCY ARCTIC OPERATIONS

115. General.—*a.* Flying operations in the Arctic present some special problems. See FM 31–15.

b. There is no necessity for abandoning hope in the event of a motor failure or crack-up in the Arctic regions. During the cold months, it is often possible in case of motor failure to make a wheel landing on a frozen surface, effect repairs, and return to base.

c. This section of the manual is concerned with emergency operations in the Arctic regions when an airplane is forced down and a take-off is impossible.

116. Special equipment.—*a.* If space is available for stowage, an inflatable rubber boat with hand paddles can be carried in the airplane when operating over Arctic seas and ocean. Inflatable life preservers would be of considerable value provided there was a possibility of immediate rescue and the rescue party had a change of dry clothing so that an immediate change could be made from wet to dry clothes.

b. The *Maine* type of snowshoe should be carried along if stowage space is available. For Arctic conditions a snowshoe would be of more value than skis because skis cannot be used satisfactorily in forests, on sea ice, or in the deep and soft snow of central and southern Alaska.

c. For summer operations in the Arctic, inflatable rubber boats should be carried when operating over large bodies of open water. When not operating over large bodies of open water and stowage space is available, snowshoes and an 8- by 12-foot, or larger, waterproof tarpaulin should be carried. By lashing the snowshoes together, a rectangular frame can be made and the tarpaulin can be lashed to this frame. This makes a satisfactory makeshift boat for crossing unfrozen lakes and rivers. A snowshoe or piece of driftwood can be used for a paddle.

117. Securing emergency equipment.—*a.* For a return to their base of operations, the crew of the crashed airplane will provide

themselves with skis, snowshoes, and sledges. These pieces of equipment can be fashioned from parts of the wrecked airplane.

b. Herein are listed several types of aircraft now in use with the flying forces and the various components of the airplane that can be used as implements for Arctic travel. The lists are not complete and are intended only as an example; the rest is left to the parties involved.

(1) *B-23.*—(*a*) Investigation of this airplane shows that the doors on the tail-wheel well are 6 inches by 36 inches in size and are secured by a piano hinge, two elevator trim tabs 7 inches by 30 inches, and one aileron tab of the same size. Under the nose of the fuselage are two detachable sections 14 inches by 20 inches, and one 14 inches by 72 inches. At the point of attachment of the outer wing panels to the root section, are covers over the joints that can be used. These will suffice for snowshoes and skis when straps, thongs, ropes, or wire are added so that the improvised snowshoes or skis can be lashed to the feet.

(*b*) For improvised sledges the following parts can be used: the four doors over the main landing gear; the cabin door, which is 2 feet by 4 feet; and the bomb-bay doors, which are 30 inches by 100 inches. They will suffice for carrying provisions or a member of the party. All of the foregoing dimensions are approximate.

(*c*) The engine cowls can be dismantled to provide lightweight sections for shelter.

(2) *B-26.*—(*a*) The two nose-wheel doors which are 15 inches by 80 inches, and the nacelle sections, which are 10 inches by 48 inches, can be used for snowshoes or skis.

(*b*) A sledge can be improvised from the four main landing-gear doors, which are approximately 15 inches by 81 inches.

(*c*) The 30-inch by 30-inch cowl sections will serve for light shelter and windbreaks.

(3) *P-39.*—(*a*) In the case of pursuit airplanes, only one man must be considered.

(*b*) For snowshoes or skis, the two inspection panels on either side of the fuselage or the nose-wheel doors can be used.

(*c*) The two cabin doors can be used for sledges.

(4) In case a forced landing is made on sea ice when no rubber boat is carried, it is possible to make an improvised raft by removing the tires and lashing them together with wire or control cables. This can be accomplished by stacking ice blocks under the wings so they will support the airplane and permit partial retraction of the landing

gear. If sufficient tools are carried and time and weather conditions permit, the fuel tanks can be removed and lashed together. Such improvised rafts will aid in crossing open leads and sea, provided the water is calm.

c. This list of airplanes is not complete, nor is the list of possible emergency equipment for those listed complete. It is recommended that the crews of airplanes engaged in Arctic operations inspect their airplanes thoroughly and provide themselves with the necessary tools for construction of the emergency traveling equipment. In addition, they should carry individual weapons, emergency rations, compass, and means of lighting a fire so as to keep warm. Sleeping bags should be permanently installed in airplanes.

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